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SIR JOSEPH PAXTON.

EDUCATION FOR ENGINEERS AT THE CRYSTAL PALACE.

WITH PORTRAIT AND MEMOIR OF SIR JOSEPH PAXTON.

ALTHOUGH Sir Joseph Paxton is known to the world by a large number of publications on horticulture and floriculture, his genius found its last, deepest, and best expression in the profession of architect and engineer, which was the sole occupation of the last eleven years of his life, and had engaged the chief of his thoughts seven years previous to that. It is a curious study to observe the course of development in men of genius. Sir Charles Wheatstone, from being a mere musical-instrument maker, combined all existing knowledge of electric telegraphy and made it available to the world, besides which he so improved his original calling as to make it a scientific pursuit. Mr. Bessemer, from the invention of small and interesting contrivances, products, and uses, rose to the highest pinnacle as a scientific benefactor by his discoveries in the treatment of iron, &c. Sir Charles Fox quitted the surgery and became the largest constructive engineer and contractor of his time, and we have now to add to these names one who, beginning life as a gardener working for a few shillings a week, rose to a seat in Parliament and a knighthood, because of the important services he rendered to his country in the invention of a new style of architecture and an improved method of arranging some details in the transit of troops during war.

England has many such self-made men. Society of the highest character is not exclusive; the exclusiveness is more intense in the lower and less intelligent strata, and it is the difficulty of cutting through the snobbery below that tries the perseverance and energy of men who, having some good stuff in them, recoil at the vulgarism, the folly, and the frivolous superciliousness which would keep them back in their struggle or keep them down in the ranks. When very young Paxton went to work as a gardener at the seat of Sir Gregory Page Turner, Battlesarn, in Bedfordshire, at a wage of fifteen shillings a week. Subsequently he was at Kensington, we believe at the gardens of Messrs. Lee and Kennedy; and at the time of his decease many of that neighbourhood remembered him busy with his wheelbarrow while there engaged. He soon went to Chiswick, where was Dr. Lindley, both young men, and they formed a life-long and mutually helpful friendship. His engagement was at the Royal Horticultural Society's garden at Chiswick, adjoining the Duke of Devonshire's seat there; and his fame commenced ominously, for his perpetual tendency to practical joking often brought him into trouble and nearly lost him his place. It happened that he had the key of a gate leading from the Duke's grounds into the garden, and he frequently used it for the Duke's accommodation when he chose to pass; moreover he always had a light for the nobleman's cigar and plenty of information about plants and flowers at command. The civility pleased his visitor and an acquaintance sprang up, but his future patron did not even know his name. When, some time after, the Duke had occasion to appoint a head-gardener for his seat at Chatsworth, he applied to the Chiswick authorities for "the young man who has that good voice, and used to open the gate" for him, the Duke being rather hard of hearing. The authorities of the society raised objections about Paxton's capacities for such a position, but these the Duke speedily overruled, and the young gardener went to Chatsworth at the age of twenty-four, and soon after married Sarah, the third daughter of Mr. Bown, of Matlock. His first duties were limited to the work of the gardens, but were afterwards extended to the management of the great Derbyshire estates. Under his skill the wild region became the wonderful place it is, drawing visitors far and near, and setting an example of that princely development of grounds and pleasances which now marks the country homes of the great English families. Its fountains and Italian terraces; rich woods laid out with such marvellous care and design; its hothouses, where the Victoria Regia was first compelled to blossom; and the great conservatory, 300 ft. in length, which was the precursor of the fairy structure in Hyde Park, described in our notice of Sir Charles Fox, and of that later one now on Sydenham Hill, all are become familiar objects of admiration. This conservatory caught the attention of architects, because with perfect simplicity it combined much beauty of form. It was constructed upon a foundation of the greatest solidity. It has an underground railway for the use of the gardeners and workmen, an elaborate and successful system of heating and ventilation, and an ingenious ridge-and-furrow arrangement of the glass for the double purpose of increasing its power of resisting hailstorms and facilitating the rapid passage of rain-water,—contrivances since common enough in gigantic glass and iron buildings, but then novel.

Respecting this, it is well to remember that ten years before the Crystal Palace project took its place in public interest, Mr. Paxton had shown his capacity in engineering, or rather, practical mechanics. For a communication to the Society of Arts he obtained the honour of its Silver Medal, describing his invention of a machine for making sash-bars on an improved principle. It is recorded in the "Society Transactions" for 1840, at p. 99:—

"Chatsworth, Derby,
"13th March, 1840.

"Gentlemen,

"I beg to submit to your notice the accompanying drawings and description of a machine for making sash-bars, which is in use at this place, and an account of which has not been published.

"In constructing the great Conservatory recently built here for His Grace the Duke of Devonshire, it was found desirable to contrive some means for abridging the amount of manual labour required, to produce the immense number of sash-bars necessary for a glass construction of such magnitude. Hence, the origin of the present machine, which, in its first state, merely performed the part of a grooving machine, but was subsequently improved, so as to make the bar complete.

. . . "As regards that building alone, it has performed the labour of twenty men for one year, and consequently saved in money about £1,200. The length of bars made for that conservatory, would in a direct line extend 40 miles. . . . The present machine was constructed for a particular purpose, which it satisfactorily accomplished. If one were to be for permanent use, the frame-work might to advantage be made of cast-iron, with polished plates for the gauge table, and the saws might be of varied character, according to the work required.

. . . "The bar is presented to the saws below the centre of motion, instead of, as usual, above it; and also to the sides of the saws ascending from the table instead of the descending sides. These arrangements were made to suit the direction of the teeth to the grain of the wood; for, when the bar was presented in the usual way, the saws crushed, instead of cut and cleaned the wood. When the machine makes its proper number of revolutions (1,200) a minute, the saws not only cut, but plane the wood, which only requires a slight rubbing with sand-paper. For very fine work a second set of saws of finer teeth can be used," &c.

"I am, gentlemen, &c., &c.,
"JOSEPH PAXTON."

The Society desired further information as to its economical results, and in his reply he states "that it was first used in August, 1838; that the motive power was that of a 4½-horse-power engine, employed on the premises for other purposes; that the machine required half its power, and was charged with half the expense, including attendance of 5*s.* a day; that it made 600 ft. in an hour, but allowing for loss of time in cooling and sharpening the saws, it turned out 2,000 ft. a day; that the material used was Riga deal and oak or other well-seasoned wood; that it only required the attendance of a man and a boy; and that its first cost was £20.

It is interesting to read the particulars and see the drawings, of which two are here given.

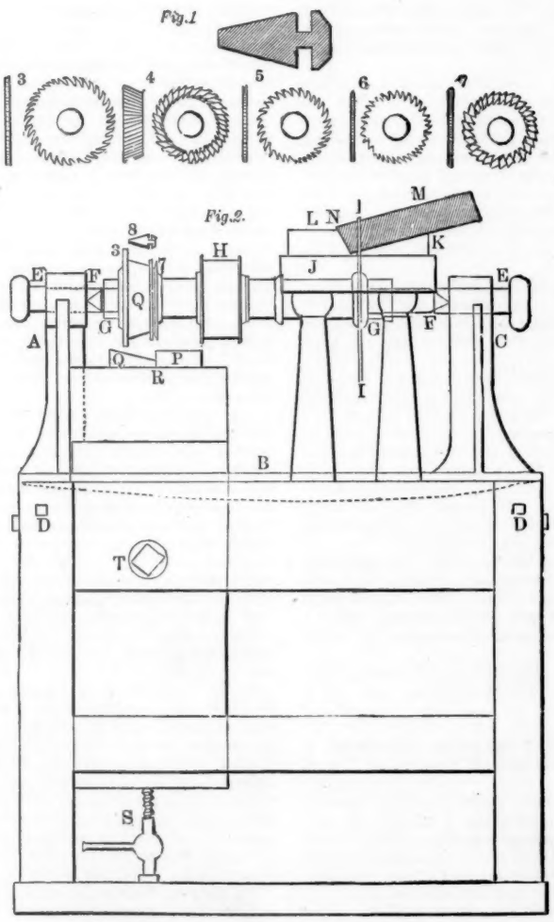
Fig. 1: section of sash-bar, half-size; the other figures are one-eighth. Three operations finish the bars like fig. 1. Fig. 2: an end view of the whole machine; A B C, an iron frame fixed across the bench D D; E E its poppets, between which the axis F F is mounted, having on it all the cutters Q, the driving pulley H, and the circular saw I I, fixed by the screw-nuts G G; J the saw-table, having on it the bed K, whose slope is made to the right level for the sash-bars; L the gauge; M a plank of the right thickness, out of which the bars are to be cut; it is shown on the bed K, with the saw I I in the act of cutting off one bar N; the plank is then laid with its upper side undermost on the bed; the next bar is cut off, and the operation thus continued, the plank being reversed for every cut; this is the first operation. Each bar, N, as it comes from the plank, is to be laid on the bed O against the gauge P, and passed under the cutter Q; this second operation finishes one side. The finishing table R is then raised a little by two adjusting screws S, one at each end, and fixed by the screw T; the bars are again passed under the cutters Q with their other sides uppermost; this third operation finishes them ready for use. The motion of cutter Q meets that of the bar, tending to thrust the bar from it rather than to draw it in.

The cutter Q is composed of five separable discs, somewhat

resembling small circular saws, of such thicknesses, and having edges at such angles, as produce the compound figures required for the bar, &c.

Paxton was proud of his success with the Victoria Regia, which flowered in 1849. At the Society of Arts in 1850, when describing his plan for the Great Exhibition, he exhibited a leaf of the plant, 5 ft. in diameter, and the growth of five days. In that speech he showed his architectural genius by pointing out that the under-side of the leaf was a beautiful example of "natural engineering" in the "cantilevers," radiating from the centre, where they were nearly 2 in. deep, "with large bottom flanges and very thin middle ribs, and with cross-girders between each pair to keep the middle ribs from buckling," their depth gradually decreasing towards the circumference, where they also ramified.

The Exhibition building could never have been accomplished by Sir Joseph Paxton if the firm of Sir Charles Fox had not taken the entire work into their own hands. As regards the Sydenham building he appears to have maintained a different position; everything was submitted and much directed by him; in particular the construction of the principal ribs—by which the arched form of roof the whole length of the nave, as well as to each of the transepts, became possible without external buttresses—was his idea; though there he was assisted by the drawings, calculations, and supervision of Sir Charles Fox. The general conception of the scheme, the direction as to the building and contents, the designs for and superintendence of the unprecedented and most elaborate hydraulic works, are Sir Joseph Paxton's, as also the artistic skill in the arrangement of the grounds. These are monuments of him that require no



PAXTON'S MACHINE FOR MAKING SASH-BARS.

panegyric. The man was a gardener, it is true, and therein alone he made a name, but it was the sparkling genius of the engineer and architect which in him became the creative force, and gave to a native love of the beautiful in nature and her capacities of reproduction, the brilliant dignity of a comprehensive architectural power that really appears to have been unlimited. As he grew his friendships multiplied, and these were for engineers, mechanical or civil, for architects, whether in stone, brick, or antique: few men of letters whose names were not among the number of his loving adherents. His great delight was to be in the society of the great masters of industry, and his greatest pleasure consisted in helping forward the young men whose genius needed the steadfast countenance of a distinguished self-made and independent man.

A few weeks before the Duke of Devonshire died—an event which occurred not many years before that of Mr. Paxton—he presented his friend and protégé with a life-policy of £20,000, and he continued still in the lucrative office of managing the Derbyshire estates. His death occurred after a long illness at Rockhills, at the northern corner of the Crystal Palace estate, on the 8th June, 1865, when he was in his 62nd year.

As before stated, Sir Joseph Paxton devoted the last eleven years of his life entirely to the vocation of an architect and engineer. Many of the most unlikely spots in the land have been transformed by his genius into charming retreats and sumptuous homes. He erected a very costly and fanciful design at Ferrières, in France, for Baron James de Rothschild; and also made extensive alterations at the seat of Baron M. A. de Rothschild, Mentmore, Buckinghamshire. The farm buildings at Chatsworth are his, and the dairy and cottage and the labourers' cottages at the same place. He also made extensive alterations and additions to Lismore Castle,

Ireland, for the Duke of Devonshire; and he laid out the grounds of Barton Closes, near Bakewell, the seat of Mr. John Allcard, whose house was mainly designed by him also.

Of public parks and the like Sir Joseph Paxton's memoir would be full. Liverpool, Birkenhead, Hull, Glasgow, Dundee, Coventry, and Dunfermline, owe to his genius the graceful public recreation grounds which ornament their several localities. The grasp of design manifest in the conversion of the enormous wood and waste on the first slope of the Surrey hills, and the substitution of fountains, terraces, and lakes for swamp, underwood, and forest, and the unveiling of a landscape of unexampled extent and beauty, surmounted by a structure of more than tenfold the beauty of its original, stands an imperishable monument to his fame and name, for there is nothing like it in the whole world. That same magic touch has been applied elsewhere in a limited form, for no private gentleman would spend a million and a half on an estate for the sake of beauty and art; but the genius is the same, and every engineer will ever feel proud of the achievements of a man who had the gift of instinctively knowing how to make the very best out of the very roughest materials.

In 1854 he was elected M.P. for Coventry without opposition, and retained the seat until a few months before his death, when he retired from failing health. In this capacity his experience in works of construction has been of great advantage. During the Crimean war he secured the establishment of the Army Works Corps of "navvies," and also designed huts of a novel form. It was owing to him as a worker on committees that the Thames Embankment was determined upon, and that the Low-Level Sewer through the Strand was made; both of them works of stupendous magnitude and immense engineering difficulty.

At his death he was chairman of the Dublin and Meath, the Manchester, Buxton and Matlock, the Midland, and the Central Argentine Railways. He was also associated with one of the very best life insurance societies—the Metropolitan—and an Indian coffee plantation.

He was elected Fellow of the Horticultural Society in 1826, and of the Linnæan Society in 1833; and in 1844 he was created a Knight of the Order of St. Vladimir, by the Emperor of Russia. He also devised a remarkable plan for girdling London with a magnificent arcade, resembling the transept of the old Crystal Palace, in which were to be included lines of railway worked on the atmospheric principle, and bordered by handsome dwellings and shops, which Sir Joseph laid, in 1855, before a Committee of the House of Commons for considering means of improving communication, &c., in London.

In 1862 he exhibited a form of hot-house of very ingenious construction. Two simple slopes from eaves at the ground to a ridge and spanning a space composed of flats, then eaves guttering resting on saddles which are hinged on the ridge; and no rafters. This admits of any movement or arrangement, either for air or space.

His remains were laid in the churchyard of Edensor, near Chatsworth, in Derbyshire, on the 15th June, 1865.

We pass now to the main object of this paper—the subject of Education for Engineers as conducted at the Crystal Palace, Sydenham.

The examples we have quoted go to prove that there are few duties devolving on parents and guardians of a more anxious and difficult nature than the choice of a profession or occupation for the subjects of their charge; and, as a corollary, the proper time to begin, and also the direction and choice of study. Properly to fulfil their obligations it has become usual to continue the ordinary process of general education until the pupil reaches the age of seventeen or eighteen years, and then to permit the choice of the future to be made by the inexperienced judgment of youth, rather than by the observation of the matured minds of those whose duty it is to have found out long ago the qualification and tendency instilled by nature or race. The education of an engineer cannot begin too soon. In the infant stage there is no difficulty in observing whether such elementary books as Miss Edgeworth's "Harry and Lucy," Joyce's "Scientific Dialogues," and the like, are acceptable and become assimilated; or whether the mind prefers "Little Arthur's History," or elementary books on Bible subjects; or whether the pencil and brush have the preference. In case the former indicates a taste for mechanical pursuits, it is surprising to note the progress, commencing at nine years of age, that can be made a capital store for the future, so that at fourteen or fifteen the school can be left, and the business of life begin, at an advantage equalling that now resulting from the expense and delay of education continued to the age of nineteen or even twenty.

In many of the schools for popular education existing forty and fifty years ago, there was a practice most beneficial in its bearing upon the future life of practical men engaged in construction and engineering. Arithmetic was taken early, and algebra reached at eleven years of age; geometry followed, and measurement, linear, superficial, and solid. The nature and relations of the triangle and right angle, and the countless forms branching from them into pentagonal, hexagonal, octagonal, rhomboids, parallelograms, became theoretically familiar by the aid of the drawing-pen, compasses, and rulers. Then ordinary field and road work succeeded, giving just such knowledge as is most useful to every one, but really invaluable to those whose life's work will have to be of such a character. The art of accurate drawing, proper planning, suitable styles of writing for such purposes, and general neatness, are acquisitions that might be as familiar and gained as early as ordinary writing, but which many an engineering student has to acquire at the cost of years labour at tormenting detail, at an age when he should be solely engaged in the higher studies relating to his future career.

In the absence of such training the boy that has natural qualifications but no money is shut out of the field unless he has friends who can afford to spend £500 upon technical education, at a time when such knowledge ought to be in possession; and even those who are willing to pay, and can, have great difficulty in finding good and qualified engineers willing to undertake such profitless and worrying child's-play. Hence come gentlemanly incompetency and parental chagrin. This fact and phase has been forced upon the attention of our best examples and indeed of the Department of Education, and in consequence there have arisen Schools of Art all over the kingdom, and now the School of Practical Engineering at the Crystal Palace; arisen, we say, but more than that, they have established the principle that a school is the best method of preparation, because the education is absolutely systematical and most truly practical. Those who have the natural taste for such a vocation and whose elementary education has been ordinarily practical, have a good chance of entering a first-class engineer's office at a small premium, and sometimes even for nothing; because such persons are profitable from the moment their engagement commences.

Those who pass the Crystal Palace at Sydenham have doubtless wondered to what use the towers of that building are applied. We have, although habitually travelling there. The south tower, near the hotel, is, then, devoted to the purposes of this School of Engineering; floor after floor, from the base, which is the fitting shop, as far up as the present demand for that kind of education requires, is occupied with the various classes of the school. Here every year, fifty students begin and complete their course of study. Besides this there is a supplementary section for Civil Engineering, consisting of two terms, and very recently another section of great promise, intended for gentlemen proceeding to the Colonies or elsewhere as explorers or settlers. These can extend their studies according to the necessities of their individual cases. We will notice these in order.

In the fitting-shop is a 4-horse-power engine, made by the students, who complete another every fifteen weeks, doing the work of the school. In this shop it is prepared and erected, and the student has to pass through a preliminary course, which consists of the squaring, turning, chipping, screwing, and drilling of a piece of inch-square iron 6in. in length. The last few days of each term are spent by the young fitters in each executing a similar piece of work, which is part of a sluice-cock, without receiving at the time any particular instruction from the superintendent; and it is the inspection of this work which enables the examiners to determine their order of merit.

On the next floor is the pattern shop, and here the pupil has to learn the general use of carpenter's tools, and execute a series of preliminary work as in the fitting shop. He is there put to the formation of patterns for the market, and concludes his course of fifteen weeks in this department by preparing for the examiners a set of patterns and brass castings, from which they decide as to his order of merit.

We proceed to the next floor—the drawing offices—where all the ordinary work of a draughtsman is done, including the preparation of working plans, sections, and elevations. This portion is of the utmost importance, because a good plan and elevation is not acceptable unless its representation on paper is respectable and accurate. In this office the art of technical correspondence is also taught. A letter is put before the student in which the writer applies for a specification and estimate for the execution of any special work, say for instance, a pump to supply a boiler; a double-purchase crab; a complete drawing and specification for a 96-horse-power engine, or the cost of a new roof, and the like. To these he has to give proper and satisfactory replies in his own language, and submit to repeated corrections until the difficulty or defect is removed.

An important feature is that of the lectures, of which there are two a week. The three terms have each a separate range of subjects. One course is devoted to the study of Steam, and subdivided into the atmosphere, the effect of vacuum on water, introduction to hydraulics, combustion, formation of steam, fuels, general construction of boilers, fire and heating surface, boiler fittings, history of the steam-engine, air-pump and condenser, rules for calculating strength of parts of engines, inertia and friction, valves, varieties of engines, pumping-engines and pumps, water supply, mains, reservoirs, tanks and filter-beds, marine-engines, various; reversing gear, paddle-wheels and screws, &c. The second term is upon Railway and Dock work. This includes the subjects of friction, coned and cylindrical wheels, axles, motive power, gradients, curves, opposing force of wind, contour lines, levelling, datum line, surveying, ordnance sheets, determining a line, walking over the ground, taking heights with aneroid barometer, trial section, bending rails, elevation of outer rails, cuttings and embankments, geological formation, tip waggons, natural slopes, viaducts, crossing rivers, sounding, swinging-bridges, ballast, fencing, draining, retaining walls, history of railways, rails and their fixings, cost of permanent way, switches and crossings, lay-byes and sidings, turn-tables, signals, electric telegraphs, block systems, stations, &c.; crossings and gates, bridges, tunnelling, girders, locomotives and cost of working, rolling stock, cranes, docks, locks and gates, ship lifts by hydraulic power. The last term takes for its subjects materials and their manufacture, viz.: timber, its kinds, weights, and uses; tools and machines for working and the cost; coal shafts and lifting gear, iron ores and fluxes, calcining, blast furnaces, blowing-engines and blasts, puddling, steam-hammers, squeezers, rolling-mills, Bessemer's converting process; zinc, copper, tin, gun-metal, and brass, furnaces; girders, adaptation of steam and hand tools, quarrying, boring and blasting, scaffolding and lifting gear. In these the students take notes and work out the examples given before the next lecture, when they are examined as before. At the end of the term the official examiner tests them in his own way.

The Colonial Section is provided with a workshop, but as it has only just commenced the number of students is small. It proposes to afford so much practical knowledge of scientific and practical work and expedients as shall enable them to utilize the means and resources at command in an occupied district. In the workshop there is roof-making and house-construction practised; and by lectures and examples general information on such subjects as surveying and levelling and simple methods of measuring heights and distances; drainage and rainfalls, sounding and gauging rivers; testing water-flow; draining streams, constructing tanks, reservoirs, and filter-beds; mechanical powers; making water-wheels, &c.; boring, &c., wells, and tubes, pumps and other means of raising water; windmills, ventilation and sanitary matters, rope-making, &c.

Then follow on the same method, knowledge and examples concerning modes of clearing, felling, and grubbing, barking, seasoning, and sawing; principles, &c., of construction of timber-works, calculation of strains, strength of material, rough carpentry, joinery, fencing, wheel-making, glazing, roofing and painting, charcoal burning, pile-driving, mortars, cements, and concretes; excavating and shifting material, blasting and making gunpowder and gun-cotton, making roads, tents, log-huts, forging, moulding, horse-shoe making, turning, &c., an acquaintance with steam and its engines. All these are bearing on the shifts and expedients of camp life, and practically aided by a little camp life in a rough district for the purposes of illustration.

The value of this department is perceptible on the most cursory observation, and it must become a most beneficial agent in the preparation of emigrants for distant lands, for it affords an opportunity of learning at home what generally has to be acquired at vast inconvenience and frequently with pain and danger. The school affords these students more discursiveness than can be allowed to those preparing for home practice, because the one cannot have too much versatility, nor the other too much concentration.

After having passed the School of Practical Engineering many enter that of the Civil Section, and all should do so. It frequently happens that persons have passed the preliminary studies and acquired an elementary knowledge of practical engineering in private establishments, or perhaps they are the sons of engineers, and avail themselves of the Civil Section to complete and enlarge their knowledge and experience. It has but two terms, each of fifteen weeks. The first is devoted to preliminary instruction in practical surveying and levelling, including the use of instruments and the preparation of parliamentary plans and estimates for various public works; the second term, to preparing specifications, estimates, working plans, and drawings for the necessary bridges and other works to be carried out by contract or otherwise. But before admission the student must pass an examination as to his knowledge of mechanical drawing and the rudiments of arithmetic, algebra, and trigonometry, because without such preparation there could not be any chance of success. The first work put into his hand is the plan of an estate, which he has to copy, in order to become acquainted with the art of plan-making and writing in the italic print adopted in such documents. This is followed by handing him a portion of a field book, that he may have some idea of the process adopted for reducing levels previous to dividing the estate into sites for building or building-plots. This, of course, involves instruction in the use of the level and the staff.

The student then takes to field work, and commences by making a chain survey of the ground which lies between the tower and the Low-Level Railway Station, taking a series of sections, with all of which he returns to the office to plot. Having finished this preliminary work, and being initiated into the use of the theodolite and pocket sextant, he enters upon a course of work of a more elaborate nature.

It consists of surveying for an imaginary railway, extending from the station of the London and Brighton Railway at the Crystal Palace to what is known as the Intermediate Reservoir, which is on the Sydenham side of the grounds, a distance of nearly a mile. Passing down the south-eastern part it passes among the lakes where the antediluvian animals are, and making in its course eight bridges of various constructions and materials, it reaches the reservoir, which is the site of an imaginary dock with a swing-bridge and lock-gates, leaving the large piece of level ground facing the terrace to be an imaginary bay. The students first walk the ground to select points for triangulation, and on the next field day they take the chain and level and field book, and go through the actual conditions involved in the prescribed idea. The ground is remarkably unlevel, and a better test-ground could not be easily found. His plans have to be made on the distorted and actual scales, and his lengths have all to be taken in reference to the field lines and the actual curvatures and difficulties. Then the whole has to be reduced from a regular survey on a large scale to parliamentary plans. He also has to make out a formulated list of occupiers and owners of the several properties through which the line passes, and specify the nature of the occupation and the exact area of each, and to make out a legal specification describing the objects of the undertaking, its description, nature and extent of contract, time required, the terms of payment, engine gradients, the contractor's plan, the regulation of supervisors, the maintenance, rules for arbitration, fencing, foundations, alteration or diversion of roads, and the like, conformable to the Standing Orders of Parliament. Then follow estimates and bills of quantities set forth in tons, price per ton, totals assorted into each description and collected into a final sheet, like the last folio of a statement of accounts.

The drawings are very elaborate. These consist of entrance to the dock; working plan of the railway, details of dock gates, setting forth all the parts in dimension and strain; lattice girder bridge, the strain, tension and compression, the box girder, every link and the tension scientifically ascertained; the cross girders, working all out according to the various thicknesses of the parts; sectional points, in all their arrangements, working out all the particulars; section of brickwork and bridge, showing the foundation and all its measurements and quantities; views and sections of cross girders; roofs of buildings; the retaining walls for dock, in section, and the estimates, all worked to the minutest detail, both as to the material and the displacement of earth or water; the swing-bridge in the same way, and finally—which is the greatest trouble—the contour plan. Besides these, in the ordinary drawing office plans are made showing the pitch of the screws; the strain of rivets, their size in full; the connecting rod, its weight and materials; cost of all material, brass or iron, and relative strength in compression, tension, and shearing, for all the parts. These belong to the engine, which has to be sketched, and then properly drawn and coloured both in view and in section. So of other machinery, as may be prescribed.

One might suppose that in the allotted period this quantity of work could not be accomplished, but we have before us the list of what one student did, and it is certified by the examiners and the principal.

A young man of eighteen entered in April, 1873, having passed his preliminary in arithmetic, algebra, and geometry. In twenty days he finished his preliminary course, in which he was occupied in drawings, specifications, and estimates, as set forth, and in addition commenced a drawing of an iron queen-rod roof of 45 ft. span; this occupied his time from May 20 to August 9, and included an examination on railways, their construction and appliances, and won first order of merit. In mechanical drawing and estimating he had the same success.

He entered the pattern shop September 8th, and finished his preliminary work in fourteen days. From September 23 to

December 12 he made patterns of piston with packing rings, a model of lengthening centre-bit and joggle joint, an expansion valve, a fly-wheel rim, adjustable eccentric; and repaired an engine, using the lathe. In moulding and casting in brass—a valve and gland, and gland for oil cup, and packing ring for cylinder. In iron—a piston and piston cover. December 13th and 15th he was examined on materials and their manufacture, and had first order of merit; on pattern-making and foundry work, a second order of merit.

On January 6th, 1874, he entered the fitting shop and finished the preliminary work in nine days. From the 15th January to April 17, he was occupied in fitting and erecting a three-horse horizontal engine, and on the 18th and 20th of April had the second order of merit in the examination on steam, securing also the same distinction on the fitting and smith's shop.

This brought him to the civil engineering class, first term, which lasted from April to August, during which time he was employed upon preliminary work, and in sectioning, surveying, sounding, contouring, traversing, &c., including the use of scales, &c., the level, the chain and tape, the pocket sextant, the theodolite, planometer, &c. In that term he prepared completely and executed preliminary section No. 1, flying section of grounds below the south tower, preliminary survey of ground below south tower, working section, trial section for railway and No. 2 of the same, survey for dock, section and soundings for dock, preliminary survey for railway; and deposited plans and sections, reference plan and contour plan, specimen of reference book and complete parliamentary estimate for railway and dock, &c.; ending with a first position at the examination.

He entered on the second term work in September and completed it in December, during which he was engaged upon setting out railway curves and in the preparation of specifications, estimates, working plans and drawings for bridges and other necessary works connected with the railway and dock, making the calculations for and preparing and executing the following drawings:—1, dock retaining wall, brick and timber; 2, coffer-dam for dock entrance; 3, general arrangement and plan of dock; 4, 5, 6, three sheets for dock entrance; 7, swing bridge for ditto; 8, warehouse for dock, with details of roof and flooring; 9, working plan of railway; 10, bridge No. 2; 11, ditto, with details; 12, bridges Nos. 3 and 4. And this is followed by five other sheets of bridges, and concludes the seventeen drawings by a complete set of estimates and specifications for the same work. He took for this the first position.

Now this is no phenomenon. The last year's successful drawings remain for inspection and instruction for a certain time after the student departs, so that a stranger can easily see what is the last thing which has been done in drawings in patterns and in engines; and he can also see what is being done in work, and see it in all the stages, for the last year's engine remains, as before stated, until that of the current year is ready.

There is another agreeable and instructive occupation that should be noticed. Last autumn the students made a party of sixty, and visited Birmingham, under the courtesy of the manufacturers there and in the neighbourhood, to inspect the great works in the town and the iron-works at Wednesbury, besides which the Earl of Dudley threw open his coal and iron mines, and the party went into one of them. The North-Western Railway rendered good service in lowering the fares, and the hotels likewise, thus enabling the party to have their two long days' observation at a cost of about 25*s.* each.

The managing committee are entitled to the gratitude of the community for thus leading the way in a method of supplying practical and scientific instruction that is at once efficient and economical and capable of great development. They are also to be congratulated in the selection of the Principal, J. W. Wilson, Esq., C.E., on whom the labour of the enterprise has fallen from the beginning, and who has brought it to the condition above described. In the Civil Section he is now assisted by his son. These gentleman have freely submitted the whole of the operations to our view, and but for their candour and courtesy this paper could not have been written.

W. S. C.

COMPRESSED COAL-DUST AS FUEL.

MR. E. F. Loiseau, of Manch Chunk, Pennsylvania, has invented a new process for manufacturing fuel from the waste of anthracite coal. A great many practical difficulties had to be overcome before it could be put in operation on a large scale, but they have all been surmounted at last, and a large factory for making the new fuel goes into operation here this week. The matter has been kept very quiet of late. All the stock in the manufacturing company is owned by a few wealthy coal and iron operators in Philadelphia and New York, and although the process is said to be amply protected by patent, the Company, for some reasons of their own, have kept their operations as much a secret as possible. The dust of bituminous and semi-bituminous coal has long been converted into fuel in Europe, by the addition of pitch or coal-tar, and used in the form of bricks in locomotives and stationary engines, but the offensive odour emitted in burning has made it impossible to use the fuel for domestic purposes. Besides, it is too expensive for general use, except where coal is very dear. What Mr. Loiseau discovered was, a method of making a fuel from anthracite dust that would burn without odour in grates and stoves, and would bear handling and exposure to the weather without crumbling. This discovery would have been of little value without the invention of machinery that made it possible to manufacture the artificial fuel at a less cost than that of coal. To contrive such machinery and get it in perfect running order has occupied the inventor for many years.

The new fuel is composed of 95 per cent. of coal-dust and 5 per cent. of clay, with a small amount of a glue-like mixture made of rye-flour and slaked lime. It is in pieces of the shape and size of hen's eggs. To make the pieces impervious to water, they are dipped in a solution of "candle-gum," a residuum of paraffine and crude benzine. All the manufacturing processes are novel and ingenious. The clay is dried in an oven on sheet-iron plates, the fire being in an iron car running on a track, so that it can be pushed forward or backward under the plates. Then the clay is hoisted up to an upper story, pulverized in a mill, and deposited in a wooden receptacle. Close at hand is an iron boiler 8 feet in diameter and 8 feet high, in which the paste is cooked by steam and stirred by revolving paddles. The paste is of the consistency of thick cream, and escapes by a pipe at the bottom of the churn. The coal-dust is drawn up on an inclined plane in small cars and thrown upon an oscillating wire screen, which takes out all pieces of slate or small chunks of coal. As the dust falls through it is carried in an endless chain bucket elevator to a bin holding five tons. Now the dust and the clay fall down into a curious little machine that measures out just the proper proportion of each, and throws both ingredients of the future fuel into a common receptacle. But while they are dropping into this receptacle they receive a sprinkling of the liquid paste from perforations in an iron pipe. Another chain elevator takes the commingled ingredients up and deposits them in a huge iron churn holding six tons, in which are seven revolving shafts, that swing their great toothed arms about in opposite directions and thoroughly mix the black grist. The substance is now of the consistency of moist sand. It falls upon a leather band, and is carried to the hopper of the pressing machine. This consists of two iron cylinders 30 inches in diameter and the necessary apparatus to revolve them. The cylinders are each indented with 870 large moulds and 56 small ones, and as the moulds on the two come together they press the soft mixture into shape, and afterwards drop the egg-like chunks upon a moving wire-cloth belt below. The larger pieces weigh 2¾ ounces each and the smaller ones half an ounce. Thus far the operation has been wholly automatic, and so it continues to the end. The egg coals, as they might well be called, must now be dried. They are dropped upon another wire belt that carries them into a great oven heated to a temperature of 250 degrees, and fall successively upon still other belts travelling in opposite directions until they have gone the length of the oven five times. When they come out they are ready for burning, but must be "water-proofed" to protect them from dissolution if caught in a rain-storm. For this purpose another travelling wire belt, across which there are upright partitions of wire, catches them and gives them a bath of two seconds in an iron tank containing a solution of candle-gum and benzine. The tank is inclosed to prevent the escape of the fumes. From the tank the coals go to a big bin called "the evaporator," which holds 15 tons. The benzine fumes rise through pipes to a condensing coil, and the recovered liquid is conducted back into the tank from which it ran into the bath. After remaining about an hour in the evaporator the coals fall upon another moving belt, which deposits them in the final receptacle—the "pocket"—from whence they roll into the coal carts.

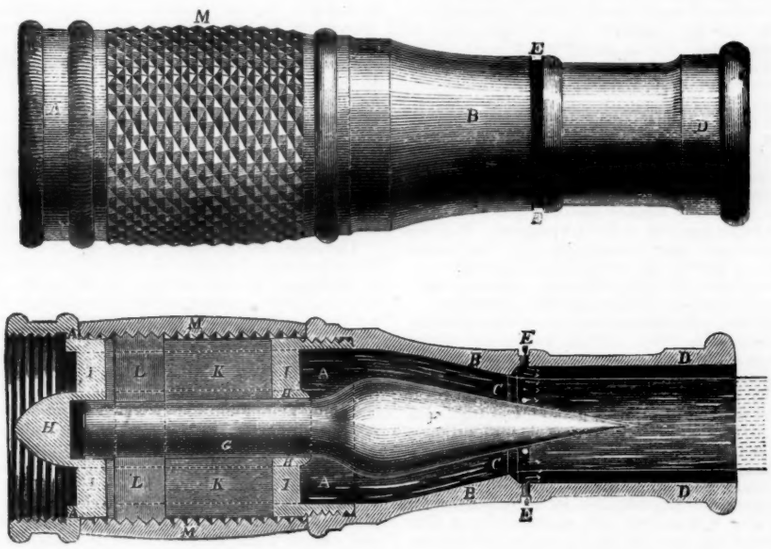
From the time the clay went into the mill and the coal-dust was emptied on the separating screen the material has travelled a distance of 743 feet without being once handled. In the succession of ingenious automatic processes lies the secret of cheap manufacture. The factory will produce 150 tons a day with one set of machinery, and the product will be sold for $1 a ton less than the price of stove coal. Contracts have been made for all the coal-dust at the Richmond wharves—the shipping point of the Philadelphia and Reading Railroad—and for an additional

supply from the Lehigh region. In the mining districts the dust accumulates in huge piles around the "breakers," and has no commercial value. The new process of making fuel therefore utilizes a waste product and develops a new industry that promises to be of great importance. The new fuel will be shown at the Centennial Exhibition in a large iron pavilion to be erected near Machinery Hall. Cooking stoves, parlour stoves, and open grates will be placed in the pavilion to show the combustible properties of the fuel. It is said that a ton of it gives 25 per cent. more heat than a ton of stove coal. *New York Daily Tribune, March* 14, 1876.

IMPROVED CONTROLLING NOZZLE.

WE illustrate herewith an improved nozzle, adapted to fire-extinguishing apparatus and for other purposes, whereby the size of the stream, and consequently the volume of water projected, may be easily controlled, or the jet be altogether shut off. There are many advantages attending this arrangement, which will suggest themselves to all conversant with the demerits of the ordinary nozzles. Perhaps the most important advantage (and the one that will especially commend itself to insurance companies) is that the device is calculated to prevent the indiscriminate flooding of warehouses, and the consequent large damage, by water, to buildings and to valuable stock. The reduced stream suffers no diminution of force, and can be thrown as far as, if not farther than, a jet projected from a common plain or ring nozzle. Consequently, in small fires, the quantity of water necessary for their extinguishment can be applied, and any surplus drenching avoided. The controlling mechanism opens and closes the nozzle very uniformly and gradually, so as to avoid the shock due to sudden starts or stoppages of the water. The hose is thus prevented from bursting, while the apparatus is rendered safe for use on hose or hydrants carrying high pressures, and on hose connected to fire-engines equipped with relief valves. Greater facility is also afforded in handling hose, by closing down the nozzle, and reducing or cutting off the back thrust of the stream.

An exterior and a sectional view of the invention are given in the annexed engravings. The nozzle barrel A is screwed into an end piece B, which has its discharge orifice C opening into a valve guard tube D, in which are air inlet holes E. A long pointed cone valve F, placed concentrically with the nozzle, has its stem G accurately fitted, but free to move in a small tube H, which is supported by two thin feather-edged wings I, fixed



transversely in the barrel. A long narrow slot K is formed through the wings and barrel, in which slot traverses a flat bar L, which is fixed to the valve stem. Said bar has rack teeth on its ends, which engage the screw threads of a milled sleeve M, which revolves freely on the barrel A, and which moves the cone valve out and in from its seat at the discharge orifice, to regulate the size of the stream or to shut off the same. The water forms on the cone a solid round jet, which does not fill or touch the tube D. A spraying attachment (not shown in the engravings) is made by placing in the outer end of the tube D a disk perforated with divergent holes, which is secured in place by a suitable cap. When this disk is placed in one position it throws a spray, and when it is turned over it throws a solid stream, in both cases backing the water up in the tube D, and making a rear spray from the holes E, which protects the pipeman from smoke and heat.

The nozzles are made in three sizes, respectively of capacity to throw a stream of $1\frac{1}{2}$ in., 1 in., and $\frac{3}{4}$ in. in diameter. These are adapted to all requirements, including those of hotels, warehouses, factories, steamships, &c., up to the largest pumping engines, and are likewise capable of throwing jets as small as $\frac{1}{4}$ in.

The inventor, Mr. Melville Clemens, of Worcester, Massachusetts, submits a large number of testimonials from the chiefs of the Fire Departments of New York, Philadelphia, Worcester, and Holyoke (Massachusetts), and other cities, and from pump manufacturers, and others, all of which indicate that the device is both useful and efficient. *Scientific American.*

ALUMINIUM AND ITS FUTURE IN THE ARTS.

IT is now about twenty years since the celebrated French Chemist, Deville, succeeded in demonstrating the possibility of producing the metal aluminium upon a large scale; but up to the present, the extent to which this interesting and praiseworthy invention has been utilized has but to a slight degree realized the sanguine expectations which intelligent minds of all professions have been accustomed to associate with it. So important, indeed, were the fruits of Deville's first investigations deemed to be, that they were at once invested with the dignity of royal patronage, and the first works for the manufacture of the new metal were shortly thereafter erected at Javelle, near Paris, from the private purse of the late Emperor of the French. It was expected that the new product would at once find its way into the useful arts as an effective and valuable substitute for many other metals. That these expectations were well founded, will be apparent from the characteristic and very exceptional properties of the metal. A bright, pure surface of aluminium possesses a greyish white colour, something between that of zinc and tin. Its extreme lightness is one of its very distinguishing properties, and affords an immediate means of identifying it from every other metal—its specific gravity is but 2·5 (water = 1), from which it appears that it is about three times lighter than copper, four times lighter

than silver, and nearly eight times lighter than gold. When struck it emits a loud, clear, musical tone, which has been compared with that of crystal glass. The keen observing powers of the French chemist did not permit this property to pass unnoticed. He suggested the employment of aluminium for bell-metal, and in the year 1868 presented to the Royal Institution of Great Britain a bell a foot and a-half in diameter, which proved to possess a most exquisite tone, and which, despite its not inconsiderable dimensions, weighed no more than forty-four pounds.

The metal may be hammered out into the thinnest leaves, rolled into plates or sheets, and drawn into the finest wire. Its hardness approaches that of fine silver, and its tensile strength equals that of copper. Its melting point lies at 700° C. (about 1,300 Fahr.), or between that of zinc and silver; and it is worthy of note that it fuses with extreme slowness, and does not vaporize even in the heat of the blast furnace. Generally speaking, the metal is workable to an extraordinary degree, and it may be filed, turned, pressed, engraved, and coined quite readily. In compact masses the metal is quite indifferent to atmospheric influences, and even when being smelted, it does not sensibly oxodize. It must be remarked, however, that the properties above enumerated are predicated from the presumption that the metal is free from impurities.

The adaptability of aluminium as a circulating medium to substitute the great variety of small coin of various compositions now employed in the different countries, was strongly urged at the outset by Deville; and as long ago as 1855, a large and beautifully executed medallion of this metal, made under his direction, and presented to Prof. Wöhler, its first discoverer, attracted much attention. The properties of aluminium, which have been appealed to as establishing its admirable fitness for coinage into money, are, in addition to its colour, *klang*, and ease of manipulation, its extreme lightness, which would serve as a perfect check upon its fraudulent imitation, and especially its indifference to atmospheric influences. In this latter respect it is far superior to silver and copper, and the alloys of these metals, at present so largely employed for this purpose. Weights of aluminium, for example, have for a number of years been employed, and have proved to be excellently adapted for the most delicate work of precision in the laboratory, retaining their accuracy even after years of use. The same admirable conservation has been remarked upon the numerous articles of luxury and fancy, which, immediately after the first public knowledge of the metal, it became the fashion to possess. Nor can it be urged with much reason that it is undesirable for coinage purposes because of the possibility of the discovery in the near future of some simple method of producing the metal from clay —which is known to contain it in considerable proportion— since this problem has been repeatedly attacked and as often abandoned as hopeless of solution; and the price of the metal has remained very constant for a number of years.

It may be considered an objection to its employment for monetary purposes, that it is energetically dissolved by a solution of soda or potash; but in reply, it may be remarked that silver and copper are equally objectionable in this particular, since they are both eagerly dissolved by nitric acid, to the action of which aluminium is quite indifferent. Upon the whole, it appears to the writer that the permanency of the metal, by which is meant its great stability when exposed to atmospheric influences and its indifference to the action of many of the usual solvent agents, and the great difficulty attending its production in large quantities, fairly entitle aluminium to be ranked with the noble metals; and when, in addition to the foregoing, its very exceptional properties are called to mind, the metal may justly claim careful consideration on the part of those who interest themselves with the question of reforming the world's circulating medium.

In the manufacture of jewellery and other articles of luxury, it is probable that aluminium may in time play an important part, though it is scarcely possible for it to ever rival the popularity of silver in these uses. In Paris, which by the way has always remained the head-quarters of the aluminium industry, it appears to be employed to a considerable extent for elegant inlaid work upon jewel and dressing-cases, fans, &c., for lids and covers of glasses, and for a variety of small articles of *galanterie*. From what has been done in this direction, we can estimate its fitness for a thousand elegant articles of taste, fancy, and utility, when once its popularity is established before the world at large, which is now scarcely cognizant of the existence of such a metal as aluminium. The clock and watch-makers' arts, the manufacturers of surgical and musical instruments, and of artificial teeth, and especially the manufacturers of fancy articles, such as seals, pen-holders, paper-weights, smokers' and sportsmen's necessaries, shirt and sleeve buttons, canes and riding-whips, harness decorations, statuettes, gas-fixtures and lamps, and of other articles too numerous to mention, would without doubt derive much advantage and profit from the employment of aluminium, and sooner or later its peculiar fitness for these uses will be recognized.

For the manufacture of philosophical and engineering instruments, and especially the latter, the indifference of aluminium to atmospheric influences and its extreme lightness, have of late met with general recognition, and the employment of the metal for these uses is steadily growing in favour.

For household utensils, likewise, aluminium has been highly recommended; but though, for this purpose as for others, neither a want of desirable properties nor excessive costliness have stood in the way of its introduction, it has been opposed by the despotic rule of custom or fashion, and in no instance with less show of reason. How much, for example, has been written and spoken concerning the danger of poisoning from the vessels employed in preparing food? How many warnings have been uttered against using copper cooking utensils, pots with lead glazing, and silver spoons that form verdigris? Were these household goods made of aluminium, we should be in possession of vessels that, so far as outward appearance and durability go, leave very little to be desired; that, furthermore, would be far more convenient to handle than the customary wares they would replace; and, what is of perhaps more importance, that would be perfectly innocuous. It appears somewhat curious that the experiment has never been tried of introducing the use of aluminium spoons. The present or prospective cost of aluminium can scarcely be offered as an objection thereto, for this is now only about one-half that of silver; while the difference in the specific gravity of the two metals is so considerable, that for the money value of one silver spoon of good quality, one might obtain no less than seven spoons of aluminium, of equal size and strength.

That prejudice and fashion are to some extent to blame for the general want of appreciation, and even total ignorance, of the eminently fitting characteristics of the new metal for a variety of uses, is very manifest; and the clearing away of such obstacles is generally a matter of great difficulty.

The alloys of aluminium are, however, worthy of special consideration, and there is a reasonable probability that a wide field of utility may be open for them in the future. Dr. Biedermann, referring to this subject, remarks, "although there is no mistaking the fact that the high expectations with which the appearance of aluminium filled the public mind have not been fulfilled, yet the aluminium industry has a safe guarantee of its existence in the use of the metal for aluminium alloys, which are capable of the most extensive use on account of their excellent qualities." The only aluminium alloys which have, however, acquired importance in the arts, are the so-called aluminium bronzes.

According to M. Morin, the director of the manufactory of Nanterre, very homogeneous alloys are obtained with copper and 5, 7½ and 10 per cent. of aluminium. The alloys with 5 and 10 per cent. of aluminium are both of a golden colour, whilst that with 7½ per cent. has a greenish tint. Even so small an addition as 1 per cent. of aluminium to copper, according to another authority, considerably increases its ductility and fusibility, and imparts to it the property of completely filling the mould, making a dense casting free from air-bubbles. At the same time the copper becomes more resistant of chemical reagents, increases in hardness without losing in malleability, and unites in itself the most valuable qualities of bronze and brass. A copper alloy with 2 per cent. of aluminium is said to be used in the studio of Christofle, in Paris, for works of art. It works well under the chisel and graver.

The true aluminium bronzes, according to Rudolph Wagner, were first made by John Percy, in 1856. As above referred to, they are alloys containing 90 to 95 per cent. of copper with 10 to 5 per cent. of aluminium. The direct mixture, by first fusion, of 10 parts of aluminium and 90 of copper, gives a brittle alloy, which, however, increases in strength and tenacity by several successive fusions. At each operation a little aluminium is lost. After the compound has been melted three or four times, however, the proportion of aluminium does not appear to change, and the alloy may be again remelted several times without alteration. These fusions are effected in crucibles. The aluminium bronze is homogeneous, and possesses sufficient expansion to fill the remotest parts of the mould. It affords sharp castings that can be worked more readily than steel. Aluminium bronze may be forged at a dull red-heat, and hammered until cooled off without presenting any flaws or cracks. Like copper, it is rendered milder and more ductile by being plunged into cold water when hot. The bronze polishes beautifully, and possesses great strength—according to Anderson's experiments, an average of 75,618¼ lbs. per square inch. The resistance to compression is feeble. From the experiments of Col. Strange, on the relative rigidity of brass, ordinary and aluminium bronze, it

appears that the last named is 40 times as rigid as brass, and 3 times as rigid as ordinary bronze.

Other experiments have shown that aluminium bronze does not expand or contract as much as ordinary bronze, or brass; that under the tool it produces long and resisting chips, does not clog the file, engraves nicely, etc.; that it is easily rolled into sheets; that in the melted state it expands very much, and is fit for the sharpest castings; but that, as it cools off rapidly, it is subject to shrinkage, and hence to cracks when the articles are bulky, hence requiring numerous runners and a heavy feeding head; and lastly, that, although not entirely unoxidizable, it is not so readily tarnished by contact with the air as polished brass, iron, steel, etc. Dr. Biedermann speaks very highly of this metal. "In the construction of physical, geodic, and astronomical instruments," he says, "it is far preferable to all other metals. In jewellery and articles of art and luxury it is employed in large quantities. Many kinds of house utensils are made of it, and it is also adapted to journal and axle boxes. Gun and pistol barrels, as well as rifled cannon, have been made of it, and have done excellent service." It has been highly recommended for type metal; type made of it lasting, it is affirmed, fully 50 times as long as those from common type metal; it has been employed for the bed of perforating machines for perforating postage stamps; and for the mainsprings of watches (90 copper and 5 aluminium), being very hard and elastic, not magnetic, and less liable to rust than steel. Its price, however, ranging as it does from $3 to $10 per lb., according to its percentage of aluminium, is probably the greatest impediment to its common use.

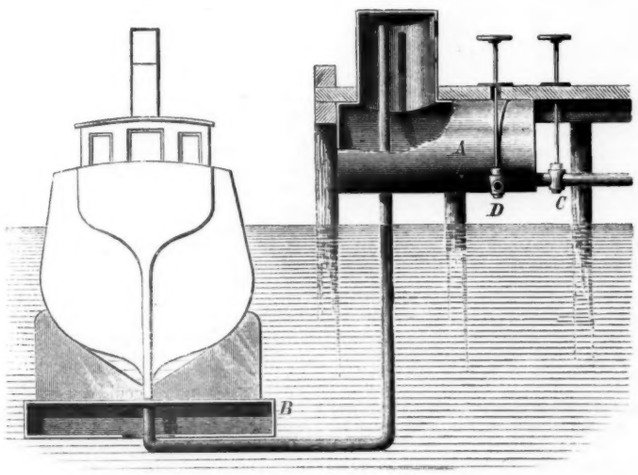
Aluminium alloys with many other metals have been made—notably with silver and iron—but none of them have acquired a permanent value in the arts. They may be passed over with the brief remark that aluminium containing 4 per cent. of silver is employed for the beams of fine balances—for which it is peculiarly fitted from its comparative lightness and stability; and that the addition of a small percentage of aluminium to steel is claimed to impart special virtues to the latter—a claim which, however, has not yet been well established.

In another direction, namely, in electro-plating and coating other metals with aluminium, numerous experiments have been tried. but thus far without practical result.

A few words more concerning the process of manufacture and the present commercial importance of the metal, and we have done. Its metallurgical production is as follows:

Aluminium is manufactured by decomposing the double chloride of aluminium and sodium, with the aid of metallic sodium. The sodium (which, by the way, has been materially cheapened in price since the establishment of the aluminium industry) is obtained by heating to redness a mixture of one hundred parts of calcined soda, fifteen parts of chalk, and forty-five parts of coal. The chloride of aluminium is prepared by passing chlorine gas over a moderately heated mixture of pure alumina (obtained either from alum, or the mineral bauxite), common salt and coal-tar. This operation is conducted in an iron gas-retort, and the result of the interaction of the several substances present is the combination of the coal-tar with the oxygen of the alumina, and the production of aluminium chloride, which unites with the chloride of sodium (common salt), forming a double salt, which volatilizes and is passed off into a separate chamber, where it condenses. From this method of obtaining the chloride, it is impossible to keep it free from chloride of iron, for which reason it is invariably present in the Parisian aluminium. From this double chloride of aluminium and sodium, the metallic aluminium is obtained, either by passing it in the form of vapour over a heated surface of metallic sodium, in a simply constructed and connected system of iron cylinders appropriately heated; or the materials are at once mixed and heated.

Rose, of Berlin, instead of the artificially prepared aluminium chloride, employed the mineral kryolite (a natural compound occurring in deposits of considerable magnitude in Greenland, and consisting of fluoride of aluminium and sodium) quite successfully. By heating this mineral with sodium, metallic aluminium and fluoride of sodium are produced, and the latter compound is gotten rid of by treating the resulting mass with caustic lime. Of late the metal has also been manufactured from the mineral bauxite.



WHEEDEN'S METHOD OF DOCKING VESSELS.

At present there are four aluminium works in existence, of which three are in France and one in England. Their total production amounts to about 3,500 lbs. yearly, of which 2,000 lbs. are produced in France, 1,500 lbs. in England. Its market value has averaged about $15 per lb., and has been for some years stationary at that figure.—*Polytechnic Review.*

NEW MODE OF DOCKING VESSELS.

THE ordinary method of raising vessels, so as to allow of repairs being made upon their bottoms, consists in floating them upon submerged docks. Out of the latter the water is then pumped, and as the dock rises the vessel is simultaneously lifted. The inventor of the new plan for accomplishing the above considers that the pumping out of the water is an expensive process, which may well be replaced by employing compressed air to enter the compartment in order to force the water therefrom, and at the same time render the dock buoyant.

This plan, it is believed, is susceptible of a variety of practical applications. As represented in the engraving, air is compressed into the tank A, and, passing through the pipe shown, enters the dock B. In order to effect this compression, the pressure of water in city mains might be used, or suitable storage reservoirs could be arranged to collect rain or surface water, and hold it in readiness to exercise the pressure when desired. In such case the water would enter the tank A, through the valve C, and, rising therein, would drive the air down through the pipe. After the water had reached a certain level in the upper extension of the tank, the valve C would be closed, and the exit

valve D, opened. The tank being emptied, would be again filled, and thus the process might continue until the desired end were accomplished.

An engine might be employed, if desired, to compress air into the tank, or any other suitable means used, which would afford a pressure sufficient, of course, to overcome the resistance of the column of water, depending on the depth of the dock.

The invention, which was patented September 8, 1875, is a simple one. For further particulars address the inventor, Dr. T. J. Wheeden, 107, Sands Street, Brooklyn, N.Y.—*Scientific American.*

MINERAL WOOL.

THE method of manufacture at the Krupp Works, Essen, Prussia, is as follows: The pig-iron furnace is provided with a tap an inch in diameter, out of which a continual stream of slag is allowed to flow and to fall a distance of 2 ft. 6 in., at which point the falling stream of slag is met by a strong blast of cold air, the effect of which is to separate the slag into myriads of hair-like threads, as white as snow, resembling the finest wool. These fibres, like spun glass, if handled, will penetrate the skin. The mineral wool is used for packing steam-pipes, boilers, &c., and is a valuable product.

THE DUTCH VAUBAN.

AMONG the many eminent Dutchmen, whose lives are almost utterly unknown to the general English reader, that of Menno, Baron Van Coehoorn, is probably the least familiar; nor is this to be wondered at, seeing that, save to those whose professional avocations would lead them to a perusal of such a biography, probably with a view to the study of that art of which he was so great a master, it offers very little that is interesting.

That little, however, I propose to pick out, it being my opinion, that in whatever way you look at a truly great man he must be always profitable company. However slight our understanding of and our sympathy with him may be, we cannot fail to gain something. We may or may not admire his particular bent of genius, we may or may not feel an affinity with the work by which he distinguished himself from his fellow-men; some moral is sure to be derived if we are wise enough to seek for it.

A mere superficial perusal of this short sketch will probably and at once lead to the thought that the hero of it ought to have lived many centuries before he had his being, that with his austere, unswerving, and indomitable will he was more fit to have been a citizen of the Spartan republic than a member of the Dutch commonwealth; but a more mature reflection will bring the reader to the conclusion—provided he be at all acquainted with history, as no doubt he is—that these two countries afford many similarities in their struggles for independence and their efforts to preserve the same. The spectacle of a handful of people battling with Nature herself for the possession of a patch of soil which the merciless, encroaching sea disputes inch by inch; the perhaps less grand but no less heroic sight of the smallest nation contesting with the then most powerful for the undisputed enjoyment of that which, by almost superhuman toil, the former had snatched from the ever-invading ocean, is surely entitled to rank with anything ever achieved by the ancients, nor will it suffer by comparison with the most glorious deeds ever chronicled in the world's annals.

That with such traditions—traditions, moreover, but freshly gathered from the mouths of those who had been leading actors in some of their principal events—a bright halo should be thrown round the career of arms, especially in the mind of a boy of noble aspirations as was Coehoorn; that it should be fostered by his surroundings, which were of a purely military character, and that it should lead, as a natural result, to his embracing from his very earliest youth a profession in which his immediate ancestors had won so much renown, is not surprising; certain is it that from his mother's breast almost young Menno was a soldier.

Behold then at the age of six or seven our embryo warrior throwing up breastworks, digging trenches, fashioning miniature bastions, aided in his childish labours by his father, an officer of no mean repute himself. Behold him a little later on, diligently applying himself to the study of mathematics and kindred pursuits, diversifying his tasks, not by the perusal of frivolous books or by indulgence in boyish games or sports, but by the reading of "Cæsar's Commentaries" and "Hannibal's Wars." Behold the stripling of fourteen, descendant of a long line of "fighting barons," dreaming already of the glories of a life such as that of the illustrious Vauban, and giving it as his determination to become the formidable rival of the great military engineer with whose fame Europe was ringing. Behold him steadfastly progressing on his path, looking neither to the right nor the left, but urging on and on to the proposed goal, and we may safely predict with his parents and friends that one day he will be the pride of his country.

Let moralists comment upon that curious twist in the human mind which seeks its highest bliss in inventing means wherewith to destroy his fellow-men; we who are not moralists, who have accepted the science of making war as an unavoidable and stern necessity consequent upon advancing civilisation, and who think that whatever is worth doing is worth doing well, cannot refrain from admiring the man who brought that science to such a pitch of perfection that even after a lapse of nearly two centuries his works are still quoted as the text-books for military students.

We need hardly remind the reader of the "Practical Magazine" that it is not our intention, in the limited space at our command, to discuss Coehoorn's system of fortification; we merely propose to give a short sketch of his career, leaving it to those whose interest may be awakened thereby to look for more detailed particulars in his own writings, the titles of which we shall supply for their information and reference.

Of his family little need be said, save that it was of old and noble pedigree, originally hailing from Sweden, but afterwards established at Frankfort, whence his great-grandfather followed William the Silent into the Netherlands, and afterwards took up his abode in Friesland, in which province Menno was born in the year 1641, on the paternal estate, about a mile or so distant from Leeuwarden. His infancy was spent as we have already seen, his further progress in mathematics being assisted by the teaching of his maternal uncle Fullenius, professor at the University of Franeker, to whom, in acknowledgment of his kindness, the nephew in after years erected a lasting memorial by naming the principal bastion of his greatest masterpiece, the fortification of Bergen-op-Zoom, after him.

A lad of Coehoorn's stamp, for whom everybody predicted the greatest future, could not well remain without attracting the notice of such a great votary to "destruction's art" as Henry Casimir van Nassau, then Stadtholder of Friesland, and it was not long before that nobleman, regardless of Menno's youth, obtained him a commission as captain in an infantry regiment then quartered at Maestricht, which town he helped to defend shortly afterwards, signally distinguishing himself by his bravery and prudence. The battles of Sennef, Cassel, and St. Denys offered him another opportunity a few years later on; and then appeared suddenly, as the result of a wager with a certain Louis Paen, a distinguished artillery officer, a treatise on the best mode of fortifying a pentagon.[1] In this work the author advanced and established entirely new principles.

The War of Independence which the Dutch had to carry on against Spain during the latter half of the sixteenth century obliged them to be continually on the defensive. Having no time and but little money to bestow upon the fortification of their towns, they were forced to find a system less expensive than the Italian, hitherto in vogue, and which students will recognize best by our simple indication of "the bastion theory." They invented what is now known as "the old Dutch system," of which Freitig and Marolois were the most able exponents. Coehoorn attacked, though in the most measured terms, the old rules, maintaining amongst other things that what are called "second flanks" are of little importance, and that the general aim which the engineer has to keep in view in the construction of a fortress is, to prevent the enemy deploying their forces, while putting his own men under cover. Not only did he demonstrate the fallacy of existing principles, but he presented his readers with a method undoubtedly superior to anything attempted hitherto. The *brochure*—it was hardly more than that—raised a host of critics against Coehoorn; most of them, as is usual in cases when the first work of a great man has to be condemned, adding bitterness of style to most insulting innuendo. Nothing daunted, Coehoorn replied to this, and clenched his argument by the publication of his "New Fortification,"[2] which was almost immediately translated into French and into English, and a copy of which may be found in the British Museum. In this book he developes three systems, which, for the sake of those

[1] "Versterking der Vyfhoek met alle Zyne Buitenwerken.' Leeuwarden, 1682. Folio.

[2] "Nieuwe Vestingbouw." Leeuwarden, 1685. Folio.

readers who are interested in such subjects, we will endeavour to explain briefly.

The first, which he formed on a hexagon, was intended to be raised on a soil underneath the surface of which water is supposed to be found at a depth of 4 ft.; the second is formed on a heptagon, and is adapted to a soil 3 ft. above water; and the third is on an octagon, traced on ground 5 ft. above water. Besides this, he aims principally at covering and flanking his works more effectually than had hitherto been done, and at depriving the enemy of the space necessary for his batteries and for his approaches, which purpose Coehoorn seeks to encompass by surrounding his works with two ditches, the foremost of which is inundated, the second dry, and having generally a width of 60 or 70 yards, serving as a manœuvring ground for the besieged, and often also for detachments of cavalry. Lastly, he builds many salient and retreating angles, so that whenever the enemy shall have penetrated into the outworks he may incessantly be harassed with cross fires.

From this short *résumé* it will be evident that Coehoorn's reason for exclusively choosing marshy soils for the sites of his systems was, that he had the interest of his native country alone in view. That he would have succeeded equally well in contriving defences for localities of any kind is manifest from the merit displayed in the construction of Fort William, at Namur, under quite different conditions. He also gave instructions for the attack and defence of every sort of work, calculating definitely and with singular minuteness the amount of expenses required in each case. It was noticed, however, that shortly after the publication of his theories, Coehoorn deviated from many of them in practice, which gave rise to the reproach from his enemies that he was far from certain of them himself. But the fact is, that simultaneously with the appearance of the Dutch engineer's book, his illustrious rival Vauban made a discovery which obliged the former to modify his own, in order to neutralize as much as possible that of his Gallic compeer. One more peculiarity remains to be noticed—that the places fortified by him offer generally far less complicated problems than he himself advances in his books; but this must be attributed to the conviction which he attained by experience, that a fortress the defence of which requires too great a technical knowledge, is, as a rule, beyond the management and above the understanding of the officer to whom it is entrusted, and is apt to damage the garrison as much as the enemy.

War having broken out again after William III. ascended the English throne, Coehoorn distinguished himself at the siege of Keizerswaard and at that of Bonn, which town the Elector of Brandenburg attacked for a long time in vain, and the surrender of which was entirely owing to the suggestions of the engineer. Full of gratitude, this prince offered him a regiment with the rank of major-general, if he would enter his service, but the Dutchman refused the offer, not wishing to abandon his native land, where many troubles awaited him, however, the following year. He who would not sacrifice his country to his personal advancement was deprived of his rank as brigadier, after having performed prodigies of valour at the battle of Fleury, with his eight battalions, two of which only were now left to him. Painfully affected by this treatment, which he knew was undeserved, and no longer wishing to struggle against the envy which was evidently at work to harm him, he tendered his resignation. But William was too well aware of the worth of such a man easily to renounce his aid. He was recalled and sent to Namur to add new works to this already strongly fortified place; the siege of which, taking place the following year, offered the unique example of the two greatest engineers of their age being concerned in the same operation, the one directing the attack, the other superintending the defence. No wonder that Vauban, after the taking of the town, had to say to Coehoorn, "I have changed the position of my batteries seven times before daring to attack your works."

Three years after, William, besieging in his turn this same Namur, which the French had still more strengthened in the interval, neglected to take Coehoorn's advice, and was on the point of renouncing the investment, when one word which escaped the illustrious engineer's lips, and which was reported to the king, made him reflect. He had him sent for, listened to him with attention, confided the entire direction of the operations to him, and saw in very few days the place in his power. The taking of Namur increased his reputation to that extent that the Elector of Bavaria presented him with five pieces of cannon. The King, William, appointed him lieutenant-general and engineer-in-chief, and gave him a magnificent Dutch regiment, authorizing him to transfer the one, which he was then commanding, to his son; but Coehoorn would not accept this last favour, because this son was still a child; neither would he ask for the command of Breda, which his friends advised him to do, and which command he would have easily obtained. In 1697, the States-General, foreseeing another war, which in fact shortly afterwards broke out anent the Spanish succession, charged Coehoorn to visit the strongholds of the different provinces, and to draw up plans to increase their fortifications. The two towns on which on this occasion he lavished all his genius were Nymwegen and Bergen-op-Zoom, the latter being even now regarded as a masterpiece in that peculiar science. Hostilities having been declared, he proposed a mode of operation, which, had it been implicitly followed and carried out, would have placed the United Provinces beyond the risk of all danger; as it happened, the only point in which it was deviated from became nearly fatal. Instead of posting the principal army between Nymwegen and Grave, at which town his mortars for small grenades were first used, it was placed between the former and Cleves. It wanted all Coehoorn's activity and prudence to prevent the disastrous consequences of the fault that had been committed, but he succeeded. He then made the campaign of 1702 under the command of Prince Nassau-Saarbruck and the Duke of Marlborough, and directed the siege of Venloo, Roermonde, and Liege. The following year he made himself master of Bonn, after twelve days of operations in the open trenches; and was charged to carry the lines behind which the French had entrenched themselves in Waas in Flanders. He executed his task with his usual carefulness. It was his last exploit. A few months after he had an attack of apoplexy, from which he recovered, but a second proved fatal.

He died on the 17th of January, 1704, at the age of sixty-four. At the time of his death he was lieutenant-general of infantry, governor of Dutch Flanders and the forts on the Scheldt, general of artillery, and director-general of the engineering department. Thus died the man who in his private as well as in his public career could lay claim to the most unimpeachable virtue. Stern almost to austerity, he was kind withal; an enemy to all frivolity, he was nevertheless beloved by all with whom he came in contact; opposed to all that savoured in the least of flattery, he enjoyed the greatest favour with the most puissant princes; not sparing of the lives of his soldiers—in which he differed from his famous French contemporary, who considered it his greatest glory to be concerned in the well-being of "even the smallest drummer in his army"—he was almost idolized by his followers; strict and just, he could be merciful where it was required; thrifty to a degree, no one ever claimed his assistance in vain; and he could refuse an appointment of a hundred thousand francs per annum, which Louis XIV. offered him, rather than forsake his country, which after all treated him but shabbily. He lies buried in the village of Wykel, in Friesland, where his children raised a momument to his memory, setting forth his worth and noble characteristics.

ALBERT D. VANDAM.

G. SIGL'S NEW WIRE-CABLE RAILWAY SYSTEM.

MR. GEORGE SIGL, the great Vienna engineer, has invented a new system of mountain railway, which, as regards cheapness, simplicity, and the small power necessary to work it, exceeds all others.

The system is designed both for passenger and freight traffic, and a working station has been built and opened to the public on the charming property of Mr. Sigl, near Vienna, called "Mount Sofienalpe," one of the most delightful look-outs in the large wood situated westward from Vienna, "the Wienerwald."

The new wire-cable railway runs from the end of the small Haltervalley, near the Western Railway Station, Hütteldorf, to the top of the Mount Sofienalpe, in a straight line of about 650 yards in length.

Here a restaurant has been established, which Mr. Sigl has enlarged by transferring there one of the great German annex-buildings, which had been erected in the year 1873 at the Exhibition grounds between the great Industrial Palace and the Machinery Hall.

The railway itself was examined and approved by the general board of inspection of the Austrian railways, who gave permission for passenger traffic, and has been in full operation.

The line when in operation offers a very singular aspect, especially the little four-seat carriages running on the rails, the latter being laid on sleepers in the ordinary manner.

Between the rails, on small sheaves, covered with india-rubber for avoiding noise, the carriages are drawn up and down by a ¾-in. wire-cable, which goes upwards in centre of the right line, turning, at the top of the hill, over a horizontal driving-wheel 8 ft. in diameter, returning in the centre of the down-line, whilst at the station at the foot of the hill is another pulley of the same

diameter (the latter being equal to the distance from track-axis to track-axis), but fixed in a more inclined position, and conducting the cable again into the direction of the up-line axis. Both at the upper and lower stations the cable disappears under the ground, vertical pulleys leading it to the great head-wheels at both ends.

The upper one of these two head-wheels is fixed in a beam which is in direct connection with the engine; the lower one, on the contrary, is mounted in an oscillating plumber-block.

The engine itself (and that is one of the most important advantages of this new system), is only a 12-horse-power portable engine; a second one of the same power has been placed in the engine-house as a reserve.

The cable has, at certain intervals in its length, iron knobs, and on the lower part of the carriages an apparatus is arranged on a screw-shaft, the double duty of which is, first, to embrace the iron knobs, when they pass under the carriage, which must before be brought in the proper position, and secondly, to stop the carriage immediately should the cable break.

It must be confessed that this double problem has been resolved in an admirable way, although it was the sole condition under which the imperial government would give permission for the employment of this system for passenger traffic.

The wire-cable in use here has been delivered by the well-known German firm, Felton and Guilleaume, of Cologne. The cable is composed of six strands of seven wires each, consequently of forty-two cast-steel wires, the total cross section of which represents about half a square inch. The guaranteed strength of the cable is 34,000 lbs.

On the occasion of our visit to the Sofienalpe, twelve waggons were continuously in motion on the cable, and two others stood in the station-house ready to be attached to the cable. As a carriage reaches the upper station, the mechanism embracing the knob leaves the latter automatically, being lifted by an apparatus fixed just over the point where the cable disappears under the floor. The greatest gradient, of 1 in 4, is on the lower part of the way, representing nearly the fourth part of the whole distance; then follows a point where the gradient changes, and is reduced by degrees to a minimum of 1 in 7.

The favourable distribution of the total load to be moved on several points of the whole distance, allows the employment of smaller engine power than is necessary for wire-cable railways of the old character, where the whole load has to be put in motion at one time. Four-and-a-half horse-power is sufficient for moving the cable and the carriages without freight, that is to say, to overcome the dead load and friction.

The carriages being arranged in the most advantageous manner, viz., when the load on the up-line and that on the down-line are in equilibrium, another four-and-a-half horse-power is all that is necessary to work the line; so that but nine horse-power is all that is required for continual work, and when the load is not in equilibrium the greatest power that is necessary is twelve or fourteen horses.

The staff necessary for the Sofienalpe Railway is composed of 5 men: 1 machinist, 1 treasurer, and 3 attendants; two of these are employed in the station-houses, to bring the carriages from one line to the other by means of a small rolling bridge, and to hang the carriages into the knobs; the third has to survey the line itself.

This system allows gradients of 1 in 2 without difficulty; indeed Mr. Sigl has actually projected a railway to the summit of Mount Vesuvius for passengers, where the last portion of the way is composed exclusively of a gradient of 1 in 2; and Mr. Muhl, the engineer of the Sofienalpe Railway, has made designs for the construction of a railway to the summit of Mount Sonnenberg, near Lucerne, in Switzerland.

The municipality of Vienna intends to adopt this system for the transport of the dead and the funeral *cortèges* from the town to the new central cemetery near Simmering, a distance of nearly two miles from St. Stephan's Cathedral.

COMPOSITION FOR COATING BOILERS.

SINCE the steam engine was invented there have been literally innumerable experiments and inventions, all tending to the development of its utility, by either adding to its powers or avoiding the many dangers to which a novel mode of mechanical power is subjected. The excellence of machinery is absolutely determined by the competition of rival inventions or appliances on the question of cost and efficiency in combination. Many excellent suggestions have had to be abandoned, just because the cost of their adoption did not cover the commercial advantage assured; and many inferior appliances have had a good run of fortune because their cost has been little, and the repeated outlay enforced by their temporary character and construction entailed less loss than a better process or invention might require.

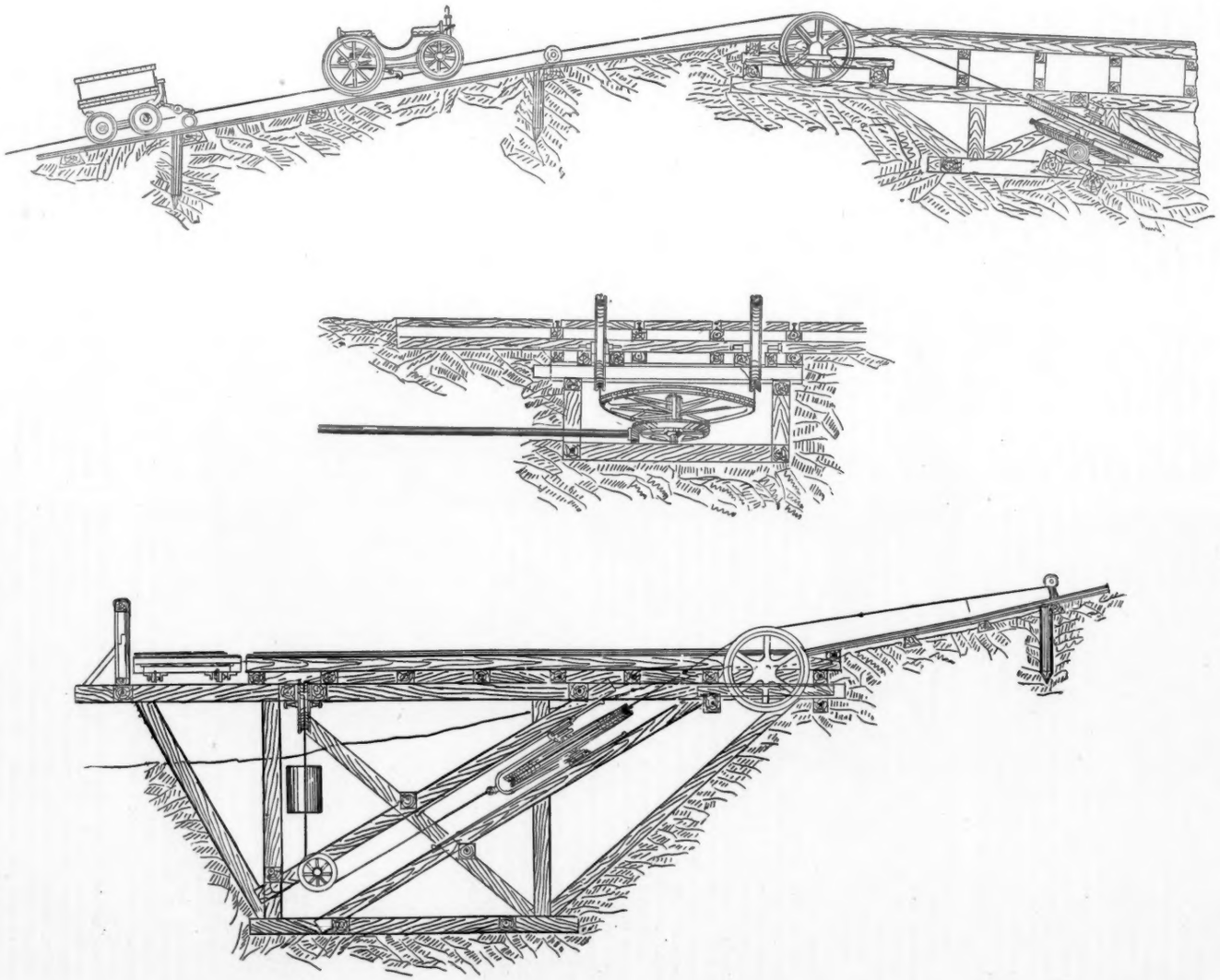
The practice of coating boilers affords an example out of many that could be referred to in confirmation of this remark. The loss of steam-power caused by the indispensable use of so rapid a conductor as iron in the construction and working of a boiler is enormous. It is perfect waste. In fact it might be easily demonstrated that heat cannot be carried beyond an easily ascertained temperature, because the atmosphere at the outside would absorb the surplus, and render nugatory all efforts to augment the force. Non-conductors must be employed. If this be the case with excessive temperatures it is manifest that for the ordinary engine of the factory, where speed at the smallest cost is essential, the same principle can be brought to bear with most advantageous results: a small boiler can thus be made effective in a singularly increased proportion. It is a well-known fact that whereas nine square feet of flue and furnace surface per horse-power is the usual proportion in waggon boilers, reckoning the total surface as effective surface, if the boilers be of considerable size, in the case of small boilers that proportion has to be increased. If that surface could be coated so as to be of no higher temperature than the hand could touch without pain, it is clear that not only is the waste of steam reduced to a minimum, but that its production is largely augmented, and in consequence it also follows that the consumption of fuel is greatly diminished; and a still further benefit is secured in the circumstance that there is not half the risk of clinker material banking up the end of the furnace and wearing it out uselessly.

The evaporating power of boilers is the main thing to be considered in their selection: but it has often been the fact that the demand upon the boiler for steam is very often reckoned contingent upon the nominal horse-power of the engine. The nominal power of an engine is, however, only a conventional quantity, by no means in uniform proportion to the actual quantity of steam produced, and hence have arisen perplexing complications and failures. In planning boilers for any particular engine, the actual power required to be produced must be ascertained, and the arrangement of boiler capacity be apportioned accordingly.

In our issue for August, 1875, p. 232, we noticed the introduction of a novelty that claimed to have an important bearing on these objects, and which claim the subsequent experience has confirmed. Messrs. Field Brothers, of Shepperton Road, Islington, apply a composition to the surface of boilers, cylinders, and pipes, or other heated surfaces, more perfectly non-conducting than any yet discovered, and possessing this further quality, that it is in itself expansive. We know that non-conducting materials are of many kinds, but the most of them are liable to contraction as the iron expands or the heat increases; and it is no wonder that such should be the case, for the material of the one is earth and the other metal. A compost that could bear the expansion and contraction is evidently desirable, and in fact a coating devoid of this property would fail to satisfy the conditions of composts altogether. This does not crack; and it does not increase in temperature beyond 150°, which in a steam-boiler is really nothing.

The owner of steam-power has great difficulty in another direction. Sometimes he is compelled to have his boiler a long way distant from his engine, and the pressure has been of necessity increased thereby to a most serious extent. Many a man has been obliged to have double the boiler power required just because of this length; for while his boiler was doing its heating power to perfection the pipes were really wasting it faster. The pipes have therefore to be coated also to the depth of two inches, and it does not matter how far the distance is, in reasonable limits, the steam is not wasted by the rush through the pipes. The lower parts of the building are thus kept in bearable temperature, and the engine has its full supply of force. Heat is retained, condensation is avoided. The pressure of steam is augmented 40 per cent.; the saving of fuel pays double the outlay in twelve months, and the little engine has been able to do the work of a much bigger brother, without any inconvenience or further outlay; whilst, in addition, the pipes so coated lose nothing in the force of their contents. Thus boiler and conductors are of augmented efficiency, rendering the machinery in fact equal to the power and service of an ordinary apparatus of 50 per cent. more recognized power.

Nor must it be forgotten that, as its composition is of earth, it can exhibit in an hour the fact of any leakage that may have supervened, and indicate its exact locality. Whether the pipes or the boilers are defective, the weakness is revealed. Not



G. SIGL'S NEW WIRE-CABLE RAILWAY.

having a combustible property, it tells the tale quite plainly and persistently. And anyone who knows engineering works will recognize the danger of accident from rust as an item to be reckoned on and provided for; by this coating that risk is avoided, as oxydization is almost impossible.

We have seen many experiments in this kind of practical engineering—for it is really within that range of subjects—and know the mortification that ensues when, after every precaution has been taken, there comes disappointment or disaster, or both. The inventor has to be sent for, and his whole work commenced *de novo*, when failure has occurred; and the *débris*, muddling up the whole place in the most irritating fashion, is a common experience. With this compost no such difficulty can arise. The changes enforced by leakage merely require the removal of a given superficial area of coating for the purpose of new plates being added, and the material so disturbed has only to be pounded and wetted, to be equally fit to do its protective work when the repair is completed. This is of itself an immense advantage, when, as so frequently happens, the convenience of many workmen and their employers and the customer is concerned.

These observations have been in a general way applicable to the ordinary boiler of the usual factory, printing office, or other machine work generally; but the marine boiler is equally benefited by its adoption. To that there are few substances which will positively adhere in the under surfaces, but this does so without doubt; and all who know the vexation and trouble of that particular description of machinery, will recognize the great benefit secured by the simple and efficacious process of Messrs. Field.

But it often happens that what is technically named "steam heat" is insufficient for the purposes required. Heat cannot by steam reach more than a prescribed temperature, which is scientifically known, but it happens that where dry heat is generated a higher temperature is produced, requiring a much greater protection, and the necessity of a composition that will absolutely prevent the radiation of heat and the condensation of steam is obvious. Our previous observations as to the augmentation of steam force in small boilers will have prepared any proprietor of machinery for the remark, that every application of heat, except that of the iron-dissolving apparatus, can have its sure guard by the use of this expansive composition; for its adhesion is secured by the combination of animal matter with the earthen and vegetable admixture.

As the matter of cost is really the practical test of all novelties, on which their introduction depends, it is well to say that with one ton, at a cost of £4 10s., 150 superficial feet can be covered by a thickness of 2 in., and that in cases where it is desirable to introduce colour, it bears that ornamentation with uniformity and advantage.

W. S. C.

THE APPLICATION OF THE SUN'S HEAT TO INDUSTRIAL PURPOSES.

WHEN fears are expressed as to the exhaustion of our coal supplies, they are often met by the reply that before this comes to pass scientific men will have discovered some substitute as a moving power. Even now, there are indications that such an anticipation is not without reason. An article in the "Revue des Deux Mondes" of May 1st, contains some interesting details with regard to apparatus and experiments made by M. MOUCHAT, with a view to discover some means of utilising the sun's heat. As far back as 1860 he first took the problem in hand, which he has since been endeavouring to solve.

To concentrate the rays of the sun to any good purpose, it was necessary to have a receiver neither too large nor too costly. After various attempts, M. Mouchat contrived a vertical copper boiler, blackened outside, covered with three concentric glass bells, and resting on a substance that is a bad conductor of heat, such as sand, brick, wood, &c. He soon increased the power of his apparatus by a metallic reflector, so as to be able to dispense with two of the glass bells. He can thus greatly increase the temperature of the water in the boiler, convert it into steam, melt sulphur, which requires a temperature of 240° F., and, after twenty minutes' insulation, raise the empty boiler to 382° F.

With this reflector, chips of wood and a plank have been set on fire in a few minutes. In a glass vessel, placed in the focus of the reflector and covered with a glass case, a kilogramme (2·2 lbs.) of tin was melted in two minutes. The same quantity of lead required five, and of zinc six. The points of fusion for these three metals are 435°, 635°, and 887° F. M. Mouchat also contrived an apparatus by which cooking operations of every kind can be easily and effectually carried on, and which is capable of being readily converted into an oven.

For all these experiments concave mirrors of metal plated with silver were used, of cylindro-parabolic form, that is, cylindrical mirrors, the base-line of which is that open curve which resembles a very elongated semi-ellipse, and is called a parabola. The reflecting power of cylindrical mirrors increases in proportion to their width, and consequently the time required to reach a given temperature varies inversely as the width. At last the inventor made use of none but conical mirrors. With these the surface of insulation is fourfold when the diameter of the mirror is doubled.

M. Mouchat did not confine himself to these experiments. His object was also to obtain mechanical effects with solar heat, and ten years ago he made trials with a machine for this purpose at Paris, in the presence of the late Emperor. He has since set up an apparatus at Tours, consisting of an immense frustrum of a cone, a gigantic lamp-shade reversed, with its concavity turned towards the sky. The frustrum is made of copper, and covered inside with a very thin leaf of silver. On the small base of the frustrum, which is closed by an iron plate, rests a copper cylinder blackened outside, the vertical axis of which is the same as that of the cone. This cylinder, which is thus surrounded by a sort of enormous collar, terminates at the top in a hemispherical sort of cap, so that it looks like an immense thimble, and is covered with a glass bell of the same shape.

This strange-looking apparatus is a solar receiver, that is, a sort of boiler, in which the water boils under the action of the sun's rays. It is intended to raise water to boiling heat and beyond that by the sun's rays, which the interior surface of the conical reflector, made of polished silver, reflects on the cylinder. Through a feed-pipe the boiler receives water from a pump to about two-thirds of its height. A glass tube and a manometer, in communication with the interior, and resting on the exterior surface of the metallic reflector, serve to indicate both the boiling of the water in the boiler, and the pressure of the steam. Lastly, a safety-valve is placed so as to allow steam to escape if the pressure exceeds the number of atmospheres desired. The engine thus offers all the security that is needed, and may be furnished with all the accessory apparatus of a steam-boiler.

The larger diameter of the reflector or metallic mirror is $8\frac{1}{2}$ ft., the smaller $3\frac{1}{4}$ ft. The height of the mirror is 2 ft. 7 in.; hence there are 43 square feet of reflecting surface or insulation. The inner surfaces are of polished silver, because it is known that this is the best metal for reflecting rays of heat, but brass lightly silvered would do as well. The inclination of the surfaces to the axis is 45°. The ancients knew that this is the best form for this sort of metallic mirrors, because the incident rays parallel to the axis are then reflected perpendicularly to that axis, and give a focus of maximum intensity. The boiler is of copper, because it is the best conductor of heat among common metals. It is blackened outside, because black has the property of absorbing the rays of heat as white has of reflecting them, and it is covered with a glass case, because this substance most readily allows the luminous rays of heat to pass through it, and prevents the same rays from coming back when they are changed to dark rays, which here takes place on the surface of the boiler.

The apparatus is arranged so as to describe an angle of 15° an hour about an axis parallel to that of the earth, and thus follow the apparent daily motion of the sun. In this way the intensity of the heat used is always nearly the same, whatever the hour of the day and the season of the year.

This apparatus has furnished interesting results, which are likely to be soon surpassed with a better arrangement. On May 8 last year, in fine weather, $4\frac{1}{2}$ gallons of water, put into the boiler at half-past eight in the morning, took only 40 minutes to produce steam with a pressure of two atmospheres, *i.e.*, at the temperature of 250° F., or 38° above boiling point. This steam afterwards rose rapidly to a pressure of five atmospheres, and might have been raised to a still higher pressure, if the thickness of the sides of the boiler had permitted it. Towards the middle of the same day, with $3\frac{1}{4}$ gallons of water in the boiler, steam with a pressure of one atmosphere rose in less than a quarter of an hour to a pressure of five atmospheres, or to the temperature of 307° F. Lastly, July 22, towards one o'clock in the afternoon, during an unusual heat, the apparatus converted more than a gallon of water an hour into steam, which corresponds to about half-a-horse-power.

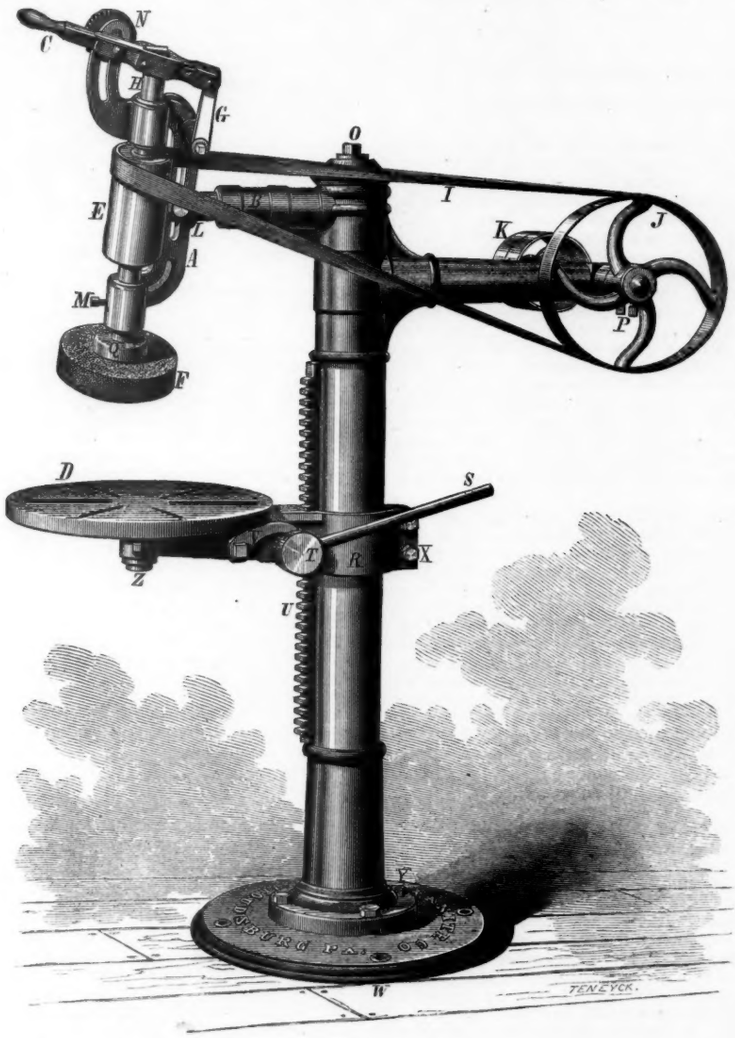
The boiler admits of the same kind of motor as ordinary steam-boilers. The cost of an apparatus like that at Tours with half-a-horse-power is not more than £60, and will be much less when the inventor has made all the alterations which he already

contemplates. Experience will lead to many improvements not yet thought of, as in the case of the steam-engine. Even in its present state the Tours solar machine is neither costly nor hard to set up nor difficult to manage, and is capable of application to all industrial purposes, especially in tropical countries, where the want of other combustible is felt.

M. Salicis, who has also been long carrying on experiments with a view to the utilisation of the sun's heat, describes his apparatus and the results obtained in a communication to the French Academy of Sciences, which appears in the *Comptes Rendus*, tome lxxxii., No. 18.

IMPROVED UNIVERSAL EMERY GRINDER.

THE machine herewith illustrated offers an excellent example of the rapid progress which is constantly being made in this country, in perfecting and refining the capabilities and designs of mechanical inventions. The reader, on turning back to the issue of our journal of last year, in which we published engravings of this apparatus, will see the difference between the old and the new form; the first being excellent in its



way, but falling considerably below the last, both in point of advantages and in adaptation of design and material to the purposes sought. In the present device the standard is of cast metal, instead of wood, and is arranged to receive a collar which supports the adjustable table D. By means of the rack and pawl mechanism shown, said table may be placed at any desired height.

The machine is especially suited to perform a large class of work, done by machinists, stove-fitters, and others, which cannot conveniently be performed on horizontal apparatus.

The wheel shaft is mounted in bearings in the frame A, which, by means of a set screw passing through a slot, is secured to a shank which enters a socket on the standard B. The shank, by loosening the set screws which confine it in the socket, can be drawn out to tighten the belt, which, acting on a pulley on the wheel mandrel, rotates the wheel; or it can be turned in the socket, so as to set the latter at any angle. By means of the slot and set screw in the frame, the wheel can be adjusted nearer to or further from the table, as desired. The mandrel has several inches traverse in the frame, so that the pulley can be pressed down or lifted up from the work by means of the simple lever arrangement at C. The lever may be set and held at any position by means of the nut shown, or the former may be counterweighted and operated by a treadle beneath the table.

In order to grind flat surfaces, the wheel is lowered down to them. A conical wheel is used for grinding holes in stove plates, &c., an aperture being made in the table, or an auxiliary platform thus provided being secured on top of the latter. For edging plates, the table can be made of sufficient size to sustain the whole weight of the plate, so that the attendant can bring a

more even pressure on the wheel with little labour, and without danger of injuring it. The wheel can be inclined so as to grind bevel edges with readiness; and by suitably formed grinders, mouldings can easily be ground.

The wheel may be adjusted to become an ordinary horizontal grinder; while the substitution of a wooden pulley for the emery wheel turns the machine into a handy contrivance for the use of an emery belt.

The machine is manufactured by the Tanite Company, of Stroudsburgh, Pa., who may be addressed for further particulars. —*Scientific American.*

THE USE OF STEAM CARRIAGES ON THE STREET RAILWAYS AND COMMON ROADS.

IN none of the appliances of the steam engine, since it was emancipated from the patents and the practice of James Watt, in the year 1800, has so little accomplishment resulted from so much ingenuity and effort as have been expended upon the use of steam as a means of transport in the ordinary avocations of life. The very earliest attempts at steam locomotion were made upon common roads, and so far as movement on these has been effected, the success attained nearly seventy years since by Trevithic has scarcely been equalled, and certainly has not been far surpassed, down to the present time, notwithstanding the great advance in the knowledge of the properties of steam and in the facilities for construction. The essays may be numbered by the hundreds. Experienced mechanics, with skilled labour applied in the direction of thorough knowledge of mechanism and of the steam engine, have vied with inventive projectors, who have possessed that ignorance which, untrammelled by educated notions to unlearn, sometimes gives scope to ingenuity and novelty; and both knowledge and invention have failed alike.

Within the past few years there has been put in use in England, as a means of hauling heavy weights, the form of engine known as a traction engine, and as the roads of that land are (and from the absence of frost can be) kept in excellent order, and as the quantity of heavy material to be removed is very great, these engines have increased, and still continue to increase, in number. Another class of engine in England, but little known in the United States, the agricultural engine, which is a power engine of small size, with its boiler mounted on wheels, to be moved from place to place, has also been made to be self-propelling. The road roller is another type of locomotive which has been quite fully introduced. None of these answer the description of steam carriages, nor does the kind of engine likely to grow from them promise much towards a Darwinian development into what will eventually be found to be employed in transporting passengers and light loads in the street, whether on the rails or on the pavement.

The mechanical difficulties to the application of steam as a motive power for carriages, have gradually come to be appreciated, and with the somewhat more complete knowledge of the conditions and requirements it is probable that the next attempts made in earnest by skilled and informed mechanics will effect more satisfactory results. It is a settled conclusion that the adhesion of the wheels, or of a pair of them, sustaining half the load, is ample for the purpose of impulsion at any grades practicable for ordinary road use, only noticing that the contact or bearing of the drivers upon the ground must be positive and uniform. A four-wheeled vehicle with axles attached to a rigid body, when standing or running on the uneven—generally twisted—surface of a road, will obviously rest or have its bearing only upon three of its wheels, and this condition of three points of bearing attaches to the tramroad locomotive, as well as to the common road one. Balance bars or gimbal-hung swinging axles will secure the equal distribution of weight upon drivers, or what in the road carriages is equally essential, on directing wheels. The possibility of driving around any curve, as the directing wheels may lead or trail, is secured by the "jack-in-the-box motion" of the traction engine, which applies the force to either driver of a pair of wheels, imparting to either wheel in whatever proportion is requisite, the motion or rotation it should have when running upon a curved line. Of course, the abrading action of the tires (like that of the faces of a mortar mill) upon the ground yet remains, and the wear on them, and on the road bed at the place of turning, will still be large; but the leverage to overcome this grinding, and the amount of grinding, will be so much less than that which accompanied the action of wheels rigidly attached to an axis that it can be surmounted or endured. The conditions of leading the tramroad carriage around the curve differ altogether from those of guiding the ordinary road carriage. The tramroad carriage will guide itself, with either the Bissel two-wheel truck, or, more perfectly still, with the old German six-wheeled waggon arrangement (in which the axles adjust themselves radially to any line of curvature); while the ordinary road carriage must have the swinging axle only for a guide.

In the application of power to the steam carriage, it is apparent that the starting resistance is the most difficult to overcome; and, although many methods suggest themselves, none has yet had practical application in service in parallel work. The utilization of the momentum of stopping may be available to help the starting of a carriage. This has already been elucidated as possible on railway trains, but in this case the gain from all the momentum lost at a stoppage bears so small a proportion to the labour of the locomotive engine, as not to be worth saving. The necessity of two speeds, at least, is acknowledged; but with the gearing of the jack-in-the-box there is no great objection to double speed wheels in addition. The total motive power of the engine demanded is about what is rated two-horse-power at the most, and the engine becomes very small. The success of the "three-cylinder engine," now made by the thousand almost in England, and its peculiar facility for the use of the expansive force of steam at high velocities, seems to open a ray of light into the darkness where the steam carriage of the future now lies. The recognition of the fact that the interstices of a mass of coal, on a given surface, present an equal area for any size of lump, whether coarse (large) or fine, only that all the lumps or grains must be sorted to the same size, is slowly being made; and as our fine anthracite coal, of pea size, runs like water, it follows that automatic firing of the small boiler will be the finality for the purpose of the steam carriage, as well as the possible finality of the firing of marine, if not all, steam boilers. This, with suitable automatic arrangement for feeding, will permit the steam carriage to be run by one man alone. Only some of the salient points of the mechanism of the coming carriage have been noticed here; others of nearly equal importance present themselves, which can be discussed or settled, in the same way, by those especially interested.

Eventually the steam carriage will be as distinctive as the locomotive engine, and will have its nationalities as the locomotive has, and its individuality, as the American locomotive of to-day has WM. MASON inscribed upon it.

The steam carriage, when in use on the public highways or tram tracks, will be much more safe from accident of any kind than the ordinary vehicle or the street car. The requirement of penalty can be made as stringent as, letting all statute laws out of the question, will allow the enforcement of common law; and under the impulse of such penalties safeguards, catchers, detentors, or arresters—automatic contrivances of all kinds—will multiply to the point that will give security to the other traffic, quite as great as that now attendant upon the average driver and the carriage horses. While the control of the apparatus, either to start or to stop, can be made certainly as effective as the present ordinary carriage, however carefully driven.

The abuse of animals (horses) in our street cars is a shocking evil, and those instincts of humanity which lead us to avoid the occasions or exhibitions of cruelty, now urge with great strength the substitution of inanimate force for so completely mechanical exertion of power. The repairs and restoration of the road-ways consequent upon the employment of horses in so large numbers, form the chief items of expense to the highway department, and the substitution of steam carriages would materially reduce this burden on the city. The removal of the horses from the street railroads alone would greatly improve the cleanliness of streets, by the prevention of so much decomposable matter now deposited upon the surface of the pavement, to be ground under the wheels to an impalpable powder, blown about with the winds, and vitiate the very air we breathe. With due regard for the public health alone, it is desirable to substitute the steam carriage for the horse car. *Journal of the Franklin Institute.*

FELL'S BOBBIN-MAKING MACHINES.

WE illustrate herewith a set of bobbin-making machines, as constructed by Mr. W. A. Fell, of the Bridge Iron Works, Windermere. Beginning with the self-acting double-boring machine, represented in our Fig. 1, this machine is specially adapted for boring round or square pieces of wood for cotton reels. It will be seen on referring to our wood-cut

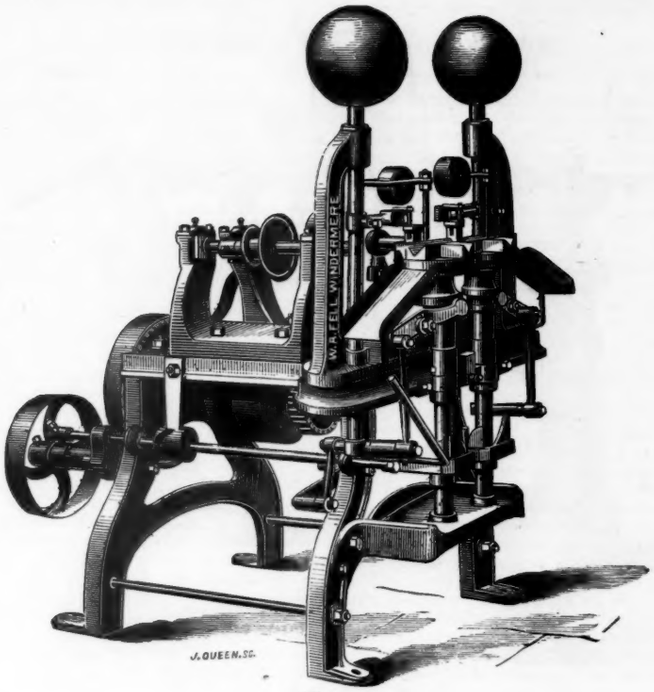


Fig. 1.

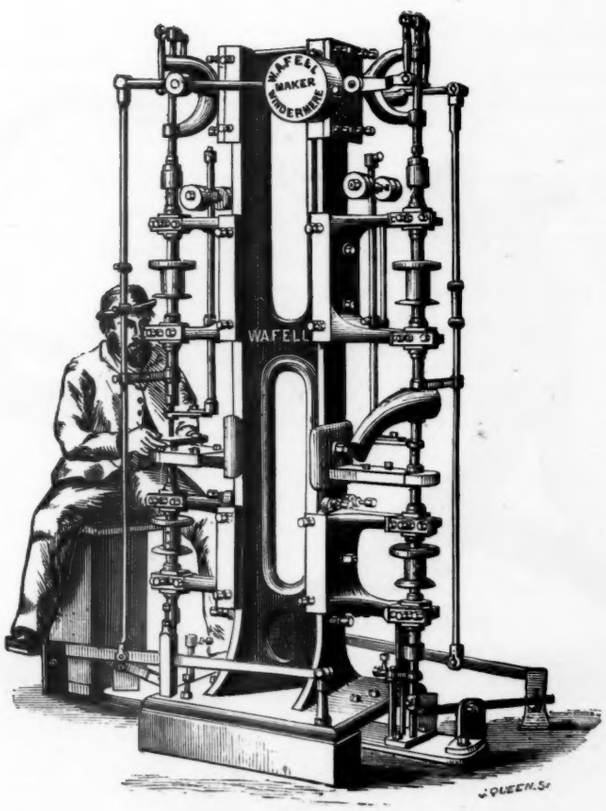


Fig. 2.

FELL'S BOBBIN-MAKING MACHINES.

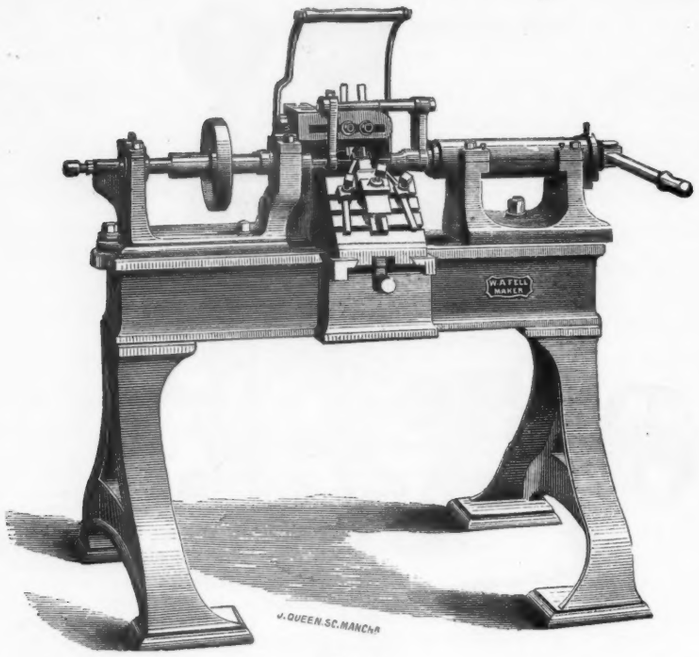


Fig. 3.

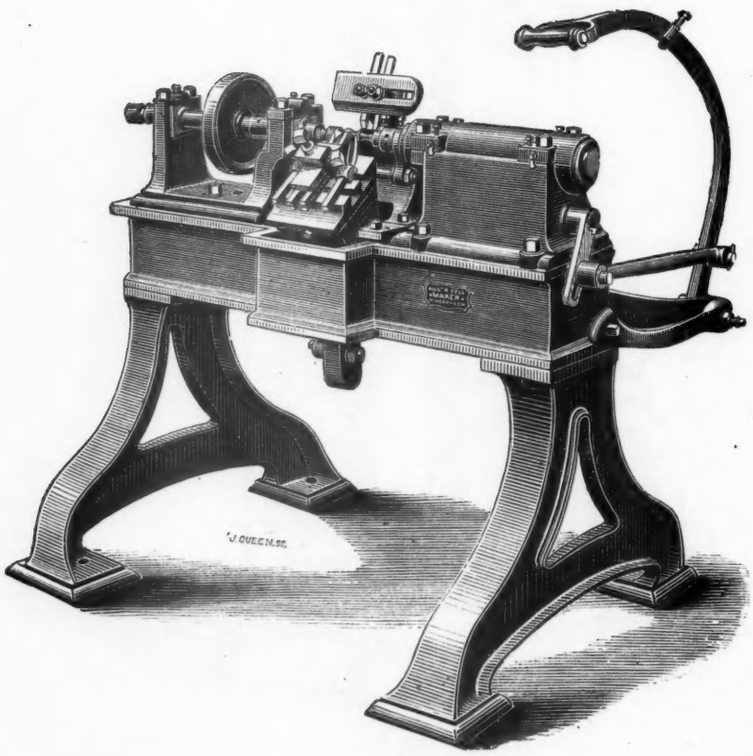


Fig. 4.

FELL'S BOBBIN-MAKING MACHINES.

that two vertical spindles placed in front of the machine, carry each one circular table; the latter have each four V-shaped grooves cast on their upper surfaces. Connected with each table is a strong upright arm, which answers the purpose of securely holding the block placed on the forementioned circular table while it is being bored. Exactly opposite the centre of these circular tables are mounted the boring spindles with horizontal traverse, and the latter likewise carry a strap pulley, which should be worked at a great speed, to ensure satisfactory boring. A lock arrangement applied to each table causes the latter to revolve one quarter round as soon as the boring bit has left the block it was engaged in boring; a knocker-off arrangement removes the bored blocks from the circular tables, and causes them to slide down the slides shown in the woodcut, from whence they may be collected into baskets placed immediately beneath these slides. A self-acting lubricating arrangement likewise oils each boring-bit before it bores a fresh block, so that it will be seen from the forementioned description that (excepting the feed) the machine is self-acting in all its movements, gripping, boring, and then knocking off the blocks, and afterwards oiling the bits.

These "self-acting double-boring machines" may be fed by a boy just tall enough to reach the tables, and its working action may be described as follows:—The attendant, to begin with, places four blocks on each table, or eight in all, or one block in each of the table-grooves. The gripping arms fall on the two blocks opposite each spindle, and hold them secure on the tables. Another self-acting movement brings the boring spindles forward, and consequently the blocks are bored by this forward movement. As soon as the boring-bits are through the blocks, the boring spindles recede, and the two bored blocks are loosened by the table dropping and the gripping-arms rising. Simultaneously the tables are each self-turned one quarter round, after which the bored blocks are pushed off the tables by the self-acting knocker-off arrangement. By the quarter turn of the table, a fresh block is brought opposite each boring-spindle, and thus there are always two blocks ready to bore at one operation. The blocks that are knocked off the table are replaced by fresh blocks; and we may likewise observe that in the feed there is not the slightest danger of any accident happening to the boy, however little he may be. With regard to the ordinary working capacity of these "self-acting double-boring machines," they are guaranteed to bore from seventy to eighty blocks per minute.

It will be observed that the machine just described merely bores the blocks, but a machine adapted for cutting out and boring cylindrical blocks of wood for cotton reels, &c., from pieces of wood cross-cut, and of the proportionate length required for the reels to be made, is represented in our fig. 2, which shows a so-called "double blocking and boring machine." As will be seen from the wood-cut, the machine consists of an upright frame, to which are bolted two headstocks, placed one above the other. Each of these headstocks has a vertical, sliding spindle, the centre-lines of which are exactly in a straight line. The lower end of the upper spindle is fitted with a tubular saw, whilst the top end of the lower spindle has a boring-bit attached. A vertical sliding motion is imparted to these spindles by means of a separate rod connecting each to a lever or treadle at the foot of the machine, and which is so arranged that as soon as the manipulator places his foot on the treadle, the upper spindle containing the tubular saw is brought down, whilst the lower spindle with the boring-bit is raised upwards. Small driving pulleys mounted on each of these spindles are driven by straps, at a speed sufficient to cause the upper or saw spindle to make 5,000, whilst the lower or boring-spindle should make 7,000 revolutions per minute. Owing to these speeds and sliding motions, the block is cut out and bored at one operation, after which it passes up inside the saw and falls into a leather trough, or from there into a tub placed at the side of the machine.

Unquestionably, the machine effects a most important saving in the labour necessary to prepare wood for thread bobbins, besides yielding a larger number of blocks from the timber; thus rough and waste timber, usually thrown away, after cross-cutting of the proper length required for reels to be made, can be worked up. One of these double machines will cut out and bore at the rate of from sixty to eighty blocks per minute. A single machine has just half the capacity of a double one, but the pillar or machine frame is so made that the additional headstocks, &c., for conversion into a double one, may be added whenever needed. The tubular saws for use in the above machines are bored from solid steel of a quality specially manufactured for the purpose, and they are turned and finished with the greatest possible accuracy. These blocking and boring machines are usually driven from countershafts.

The bobbins are now ready to receive their form, and this is done in the finishing machine, shown in figs. 3 and 4. Both of these machines give the finishing stroke to the bobbin, and merely differ from each other in the lever arrangement for working the machine. Referring to fig. 3, the slide bed and gauntree are in one solid casting, and after the headstock and spindle and slide headstock have once been set true, it is almost impossible to displace them. By this arrangement much larger reels can be made on the machine, since they are not easily knocked out of truth.

The finishing machine represented in fig. 4 is more adapted for making small reels, and is known as "the half self-acting finishing machine." It is so arranged that the man in charge merely pulls down the handle shown with his right hand, which pushes the block to be turned on the arbor, and brings forward the beds and cutters at one movement. The attendant feeds the machine with his left hand, and can finish from thirty to forty small reels in a minute.

In these bobbin-making machines steel spindles and best white metal bearings are used, excepting for vertical journals and traversing spindles, &c., when a superior copper alloy is introduced. In our opinion Fell's construction is certainly preferable to Toff's system, since with the latter only long pieces of wood can be advantageously used. Although Toff finishes his bobbin in a single machine, Fell's construction shows cleaner work, and admits of the smallest pieces of waste wood being turned to good account. A certain amount of danger is also inherent to Toff's machines, inasmuch as in the feeding of the machine, the wooden block frequently flies out, and places the workman in danger of being caught; this disadvantage is certainly not shared by Fell's system, and, owing to these chief reasons, and knowing the two systems in actual working order, we are inclined to believe that Fell's bobbin-making machines will be found to answer their purpose well.

Chemistry applied to the Arts, Manufactures, &c.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

§ 1. *Acids, Alkalies, and Salts.*

IMPROVEMENTS in the Manufacture of Soda and Potass.—In the process of LEBLANC, for the manufacture of soda and potass, it is customary to put in all together a charge of sulphate of soda (or potass), coal, and carbonate of lime, this latter being in larger quantity than that indicated by theory. Mr. JAMES MACTEAR, who recommends the use of rotatory furnaces, has employed two methods:

1. He puts all the substances of a charge in the furnace, and completes the heating; but in this case the soda is liable to vitrify, and become partly insoluble.

2. He puts the carbonate of lime and part of the coal first into the furnace and heats them, to get caustic lime; then he puts in the sulphate of soda with the rest of the coal. The immediate addition of caustic lime to the mixture of chalk, sulphate of soda, and coal, does not give good results.

The following is Mr. Mactear's process:—He mixes the sulphate of soda, coal, and chalk in theoretic proportions, and heats till the re-action is complete. He then adds 10 per cent. of caustic lime crushed, and when this charge has been well mixed with the other ingredients, he takes the whole out of the furnace. The addition of the lime at the close of the re-action renders the steeping in lye much easier. *Bulletin de la Société Chimique de Paris, May* 5, 1876.

A new Source of Sulphate of Potass.—The success with which potass has been obtained from the salt abundantly furnished by the Stassfurt deposit, led mineralogists to seek for deposits of similar salts in other parts, and the result was the discovery, at Kalusz in Galicia, of a considerable bed of an ore, which occurs there in lumps as large as one's fist, of a yellowish grey colour, more rarely yellowish white, impregnated with water, and from which chloride of magnesium may be extracted. This mineral, to which the name of kainite has been given, contains potassium, sodium, magnesium, chlorine, and sulphuric acid, as well as a fine grey clay containing iron, and a large proportion of water. Oxides of iron and manganese

have also been found in a soluble form. M. Schwartz, who has made an analysis of this mineral, found that it was composed in great part of *schænite* ($K^2\ SO^4 + Mg\ SO^4 + 6\ H^2\ O$) or sulphate of potass and of hydrated magnesia, chloride of sodium, chloride of magnesium, and clay. After many experiments, he pointed out the following mode of treatment by which these ores may be made to yield sulphate of potass, which can afterwards be changed to the carbonate by known methods.

1. Kainite contains, on the average, 50 per cent. of schænite, 30 per cent. of chloride of sodium, and 13 to 15 per cent. of chloride of magnesium.

2. A treatment with cold water, as also by crystallization or precipitation, is troublesome and difficult. At the most only part of the chloride of magnesium is thus eliminated, which, however, is useful for further operations.

3. By the cold treatment, when there is crystallization of the sulphate of sodium, or treating with red heat by the action of steam, or raising to a high temperature with coal, the combination of magnesium is only imperfectly eliminated.

4. The sulphate of calcium, heated in the form of tempered plaster or a natural plaster, precipitates sulphate of potassium in combination with lime. An excess of this plaster is beneficial, but the presence of chloride of magnesium partly hinders precipitation.

5. Lastly, sulphate of potassium and of calcium is dissolved by boiling water, which dissolves the sulphate of potassium and leaves the sulphate of calcium, which appears again in the operations. *Polytechnisches Journal.*

Direct Manufacture of Ammoniac and Hydrochlorate of Ammoniac by means of the Nitrogen of the Air.—M. SOLWAY, of Brussels, has devised the following processes for the above purpose. In a limekiln, or any other furnace where combustible and limestone, or any other base, are consumed, a current of steam and air is passed through the incandescent layer. With the combustible or base is mixed a decomposable chloride, as *e.g.* chloride of calcium, or hydrochloric acid gas is brought in at the same time as the steam and air.

Ammoniac may also be obtained by suitably heating a cyanide in a retort. The process consists in adding to a mixure of coal and base (baryta or any other) in a retort, a chloride capable of being more or less decomposed by heat, and afterwards employing the current of air and steam. Hydrochloric acid might still be mixed with the gaseous jet before it is passed into the retort. *Revue Industrielle, May* 17, 1876.

The Distillation of Sulphuric Acid.—The boiling of sulphuric acid is a delicate operation, in consequence of the irregular disengagement of bubbles, which cause overflow of the liquid and often rupture of the crucible. It is customary to make use of platinum wires put into the liquid to facilitate the disengagement of the gases. M. RAOULT recommends for that purpose the use of the charcoal retort, which renders the distillation very regular. The distilled product contains about 20 cubic centimetres (rather more than a cubic inch) of sulphurous acid per litre (1¾ pint), and this acid is then carried off by a current of dry air. *Revue Industrielle, May* 10, 1876.

§ 2. *Metallurgy.*

Iron Rails with Bessemer Steel Heads.—Experiments at the Wyandoke rolling mills near Detroit have led to the most satisfactory results by means of the following process :—

A bundle is formed as for ordinary iron rails. For the head, steel waste is added of suitable thickness, and a steel plate is put above. Into the bundle and above is introduced a solvent composed of 55 parts of iron, 20 of silica, and 25 of aluminium. The whole is heated and rolled. It is maintained that the silica seizes on the alkalies, and the aluminium eliminates the free oxygen, phosphorus, and sulphur. At any rate, the metal obtained is perfect in homogeneity and texture.

Phosphorous Bronze.—The applications of this new metal to the cables of mines are extending in the mines of Germany and Belgium. Engineers of undoubted authority recommend its use, because it possesses a very superior strength, and is not liable to rust. Hitherto the difficulties experienced in rolling and drawing phosphorous bronze have limited its production, but the period of trials may now be considered at an end, and the new metal will be brought into extensive use in the manufacture of tuyeres, cables, and special plates. *Revue Industrielle, May* 17, 1876.

Manufacture of Sulphate of Copper.—Mr. J. H. BENNIS, of Liverpool, has lately pointed out a very simple method of manufacturing sulphate of copper or blue vitriol. For this purpose, he passes sulphurous acid gas and steam over metallic copper completely granulated in a re-action chamber. This re-action is developed at the same time that there is condensation of steam, giving rise to a liquid of sufficient density for furnishing spontaneous crystallization of sulphate of copper. *Technologiste, April* 29, 1876.

The Extraction of Sulphur from Ores by Distillation.—Instead of retorts, Mr. ROSS makes use of a series of plates or tablets, forming very shallow vessels, of metal, glass, or fire-proof clay, placed one above the other, or side by side across a furnace, closed chamber, or boiler, and communicating with a condensing chamber. The substance is reduced to the state of powder, and put on the plates in thin layers of about three-quarters of an inch. The heating is effected by means of super-heated steam at 752° F., surrounding the vessels, or air carburetted with petroleum vapours, or boiling oil. The temperature is sufficient to cause the distillation of the sulphur. *Moniteur Industriel Belge, April* 20, 1876.

Silvery Alloys.—M. A. PARKER recommends the following silvery alloys :—

Copper	70
Manganese	30
Zinc	20 to 35

This composition at red heat admits of being rolled and beaten. If there is no occasion to subject the alloy to a high temperature it may be prepared thus :—

Copper	49
Manganese	21
Iron	5 to 10
Zinc	5 to 10

The proportions may be varied, but the solder necessary for all these alloys is thus composed :—

Copper	7
Manganese	3
Silver	1 to 2

Technologiste, May 20, 1876.

Steel Rails in America.—During the year 1875 there were placed on the line from Pittsburgh to Philadelphia 6,896 tons of steel rails. This quantity was more than sufficient to renew the permanent metal of the double line.

Steel rails have been substituted on part of the Harrisburgh and Lancaster line, and at various points where the traffic is greatest. On the New Jersey lines 4,372 tons of steel rails have been laid. Before 1877 the New York section, and those of Amboy and Belvidere, Delaware, will be renewed with steel rails. The Philadelphia and Erie line has already received 4,173 tons of steel rails. Hence it appears that the Americans are far from slow in their movements.

The Speedy Corrosion of the Iron in Iron Railway Bridges.—It has often been observed that the iron of iron railway bridges shows a great tendency to corrosion under the influence of the smoke, steam, and hot gases of the locomotives passing under them. The corrosion sometimes goes so far that the beams and rods in the upper parts of the bridges are eaten away to a depth that endangers the whole bridge. This circumstance induced Mr. W. KENT to examine the immediate causes of the speedy corrosion, in order to ascertain how it may most effectually be prevented. It was natural to suppose that the chief part of the corroding substances would be found in the rust.

For the purpose of the investigation, a rusted piece of iron from a bridge over the Pennsylvanian Railway was taken. Originally about one-third of an inch thick, it was in some places so friable as to be crumbled between the fingers, and in others could be shattered into small pieces by a slight tap with a hammer. The surface was covered with a red coating. The rust underneath did not differ in outer appearance from ordinary iron rust. A part of it was finely powdered and extracted with distilled water. The fluid, which was filtered off a fortnight afterwards, gave out a bituminous odour, but had a neutral reaction, and was covered on the surface with a thin oily film, which Mr. Kent thinks may have been a product of the dry distillation of coal. The qualitative analysis gave as the component parts, iron, ammoniac, sulphuric acid, and chlorine. Oxides of nitrogen were absent. In a separate portion of rust considerable quantities of carbonic acid were found.

The result of the investigation shows the causes of the speedy

oxidation of the iron, for carbonic acid and sulphuric acid are alone sufficient to produce speedy corrosion. The sources from which these substances arise are the products of the decomposition and combustion of coal, which the smoke conveys to the iron in continually renewed quantities. The special action of each of the substances is partly known. Calvert has shown that carbonic acid in the presence of moisture causes corrosion of iron, and even very diluted mineral acids have a powerful oxidising action.

In order to ascertain the action of sulphuric acid on iron, Mr. Kent brought it to act in a gaseous form on clean bright turnings of wrought-iron, as well as on old rusty lath-nails, previously moistened with water. The experiments showed that sulphuric acid in the presence of iron oxidises powerfully, and changes the iron to proto-sulphate of iron, with the formation of smaller quantities of oxide. The turnings and nails, after eight days' action of the acid, had lost about 1 per cent. of their original weight. Hence, it is easy to understand the rapid oxidation of the iron in iron bridges, for all the conditions favourable to the production of corrosion are there. To the action of the acids is further added that of the carbonic coating, which on the one hand retains the acid moisture like a sponge, and on the other by its electro-negative action with regard to the iron calls into exercise an oxidising galvanic action. To prevent oxidation effectually, a coating must be found for the iron such as to counteract the effect of the smoke, steam, and gases, without attacking the iron—a problem which it is to be hoped will not remain long without solution. *Dingler's Polytechnisches Journal.*

Process for Hardening Zinc.—Messrs. BOIGNOL, FARJON, and DELPIERRE have succeeded in changing the soft pasty character of zinc by pouring into the metal, while in a state of fusion before casting it, a proportion of sal ammoniac, varying from a tenth to a fifth of the zinc, according to the degree of hardness desired.

The metal thus obtained is worked at the lathe and the file, and may, in many cases, serve as a good and cheap substitute for bronze. *Technologiste, April* 8, 1876.

Reduction of Metals in Capillary Spaces.—If a slit tube, containing a concentrated solution of nitrate of copper or chloride of cobalt, be plunged in a bath of monosulphide of sodium, a phenomenon of endosmose is produced, in case the slit is not too narrow, in consequence of which there is formed in the solution of copper a metallic sulphide, which is precipitated against the sides of the tube. In the slit itself a precipitate of brilliant metal is formed. In this way cobalt, copper, platinum, &c., have been obtained in a state of purity. *Revue Industrielle, April* 26, 1876.

A Good Fire-Luth for the Soldering of Iron and Steel with Hard Solder.—When iron or steel articles are soldered with solder that is hard to fuse, such as copper, German silver, or brass, they require exposure to a high temperature approaching white heat for some time, especially in the case of the two former metals, that the solder may have time to become sufficiently fluid and fill up all the crevices and soldering seams. But at this temperature the oxidation of iron and steel in blast-flame, where soldering is generally performed, is very powerful, so that the articles to be soldered, unless protected from the heat, suffer severely in particular parts, especially those that project and are thin, and would consequently lose shape, in fact would be, to all intents and purposes, consumed.

To prevent this, they are usually surrounded in the soldering seams and neighbouring parts that are exposed to intense heat with a fire-luth of loam, so that only a small part of the soldered joining is in some degree left uncovered, that the melting of the solder may be observed. This loam luth, however, does not answer perfectly, for unless the loam is very slowly dried and subjected to heat it is apt to crack, and in those places oxidation goes on as actively as if there were no luth. And even if the loam does not crack, it is far from being a sufficient protection against oxidation. Moreover, it burns readily in some places, *i.e.*, it forms with the oxidulated iron of the article and part of the flux a very hard, adherent, black, slag-like coating, which cannot be removed without long beating with the flat side of a small hammer or the use of a good file, which is itself thus injured.

Herr Rust recommends the following fire-luth, composed of one part of powdered fire-proof clay and two to three parts of powdered charcoal, according as the clay is richer or poorer. These are to be mixed with water so as to form a thick pap or thin dough, and applied as the loam is usually. This luth can be very quickly dried and heated without cracking; protects from oxidation far better than the loam luth, so that the soldered articles sustain scarcely any more injury than if they were exposed to only red heat; and can be very easily removed after the soldering and plunging of the hot article in water. *Bayerisches Industrie-und-Gewerbe-Blatt, April*, 1876.

A Block of Silver.—The "City of Havannah" steamer lately landed at New York for Philadelphia, a block of pure silver, said to weigh 45 cwt. 20 lbs., to measure 3 ft. long and 1 ft. thick, and to be worth £12,800. It belongs to Messrs. Pio Bernejello and Co., Bankers, of Mexico, and is to appear among the Mexican productions at the Philadelphia Exhibition.

A Method of approximately Estimating the Weight of Long Pieces of Iron.—The following is a very simple method of getting the approximate weight of iron rails, beams, &c., when means of weighing are not at hand. First measure a yard of the rail, then, starting from this point, divide the remainder into two equal parts, and put a square-edged support under the bar at the middle point. Supposing the rail of uniform size and density throughout, the two equal portions will balance each other. If, therefore, a weight is placed at the end of the bar which counterbalances the weight of the yard at the other end, and this weight is multiplied by the length of the rail in yards, the weight of the whole will be found with tolerable exactness. *Moniteur Industriel Belge, April* 20, 1876.

Improvement in Wire-Drawing.—Mr. WARRINGTON, of Camden, in New Jersey, has suggested a new method of re-heating wires or metallic plates, subjected to the action of the draw-bench, by means of electric currents, which raise them to the temperature required.

It is known that on account of the increase in the density, and consequently the hardness of the metal after it has passed through one or more draw-plates, it is necessary to re-heat it. Hence the wire is usually heated and then allowed to cool. To avoid this tedious and troublesome operation, Mr. Warrington proposes to heat the wire at the time when it passes through the draw-bench by means of an electric current passed across, between two fixed poles, with which it is brought into contact as it advances.

These poles consist of two bars of isolated metal, placed between the draw-plate and the reel, and having a slight elasticity, which keeps them in contact with the wire. To these bars are attached wires in communication with the opposite poles of a galvanic battery or electrical apparatus. These wires serve to conduct from one bar to the other the current, which raises the portion of wire that passes to a temperature varying with the intensity of the current, and as the wire advances in continual contact with the bars, it is necessarily raised to a great heat, and quite in a glow before reaching the draw-plate.

Various arrangements, described by the inventor, are intended to avoid accidents when several reels are employed, and the draw-bench has several draw-plates, and also to provide for the breaking of a wire, so that the work may go on with the others without interruption. *Technologiste, April* 8, 1876.

§ 3. *Dyeing, Calico Printing, Bleaching, Tanning, and allied Subjects.*

An improved Process of Tanning.—A French patent has been obtained by M. TRAMIER, of Marseilles, for a rapid method of tanning hides by the injection of a mixture of carbonic acid and air in variable proportions, according to the condition of the skins. This mixture is directed by means of a pump to the lower part of the vats, in which the hides are placed with a solution of tannin in water. The vats are fitted with tubes containing capillary holes through which the gas passes and thus keeps up currents of bubbles which, continuously renewing the action of the tannin on the surface of the hides, dilate their pores, and facilitate the absorption of the tannin by the gelatinous and albuminoid substance of the hides, so as to convert them quickly into leather of good quality.

Machine for Removing the Wool from Sheep Skins.—Sheep skins consist of two distinct things, each having its own value; the skin, destined to be converted into leather, and the wool, to be employed in manufacture. It is of importance that the skins should be treated so as to injure neither the hide nor the wool, to allow of a perfect separation of the one from the other, and not to create any difficulty in the classification of the wool according to quality.

In M. FREY'S machine these three requirements are met most

satisfactorily. First, the skins are wetted on the inside with a liquid acting like sulphide of sodium. Then two skins are placed together with the insides face to face, and a number of pairs are piled up. After about an hour the wool easily separates from the skin, and the machine is brought into use.

This latter is composed of a cylinder covered with india-rubber, on which the skin is fastened by a very simple arrangement. This cylinder turns with little speed, and the skin is thus slowly brought under the action of a cutting cylinder furnished with blades, in the form of a screw, and moved round its axis with great rapidity. The knives separate the wool from the skin, and spread it out immediately on an endless cloth. The skin deprived of wool is then removed from the cylinder, and another put in its place. As to the sorting of the wool, it is easily effected, because the substance is laid upon the endless cloth exactly in the order it occupies on the skin. *Moniteur Industriel Belge, April* 20, 1876.

Improvement in Bleaching Wool.—Wool, after having been freed from grease, is bleached by the action of sulphurous acid gas as follows. An isolated chamber without chimney is selected, having a trap-door at the top, which can be open or shut at pleasure, and below a door about the height of a man, with two small openings at the corners to receive the sulphur pans. Poles about 3 yards long are placed across the chamber, and on them is laid the wet wool. To prevent the volatilised flour of sulphur from settling on it during the operation, it is wrapped in white cotton cloth.

When the chamber is ready, the trap-door is closed, and its edges are covered over with clay. Then a pan of sulphur on fire is put through each opening, and both are closed. For 100 kilogrammes (220 lbs.) of wool, 2 kilogrammes (4½ lbs.) of sulphur are employed. This substance is changed into sulphurous acid gas by means of the oxygen of the air, and this acid, condensed by the water which moistens the wool, re-acts on the colouring matter, and causes it to disappear.

At the end of twelve to twenty-four hours, according to circumstances, all the apertures are opened, that the outer air may enter the chamber, drive out the excess of sulphurous acid gas, and dry the wool. In winter, as soon as the suffocating smell is dissipated, the door and trap-door are closed, and the wool is dried with fire in chafing-dishes. Usually after the wool has been subjected to the action of sulphur, it is first put into hot water to get rid of the sulphur, and afterwards into a light soap bath to make it more mellow. It is then tinted with a carmine or an acetate of indigo, alone or with alumina.

Wool bleached by means of sulphurous acid gas soon gets yellow by contact with the air. This disadvantage may be obviated by a more or less prolonged immersion of the wool in a solution of sulphite of soda, with the addition of hydrochloric acid. The salt is put into the bath in large crystals, so that its solution in the water and decomposition by hydrochloric acid going on gradually, the wool may remain longer in contact with the sulphuric acid which is set at liberty. The bleaching is thus more complete. The yellowest and commonest wools are made of a beautiful and lasting white colour by this means. Spun wool thus bleached is always of a finer whiteness than what is so treated in the fleece.

The process of bleaching by sulphite of soda is excellent, but has the disadvantage of being rather slow. A skilful chemist has found the means of simplifying and hastening the process by the use of bisulphite of soda. This product, which is liquid, and known in commerce as *leucogène*, is manufactured by the inventor, M. CLAUDE, at Rouen. Bleaching by bisulphite of soda is as simple as by sulphite of soda. All that is necessary is to put into a wooden trough a certain quantity of water, add about a twentieth part of bisulphite of soda, and 2 or 3 per cent. of hydrochloric acid. The re-action will then take place. The wool plunged in this liquid being in contact with the sulphurous acid as it is forming, the bleaching takes place more quickly. On being afterwards exposed to the air and dried, it becomes perfectly white. This white may be rendered still more beautiful by the addition of a little bisulphite of indigo, so as to give the wool a slightly azure tinge. *Moniteur de la Teinture.*

A New Tanning Plant.—It is stated that for tanning purposes oak bark is surpassed by the Western tannin plant, *Polygonum amphibium*, which grows abundantly in the Missouri valley. It contains 18 per cent. of tannin, or half as much again as the best bark, and at large establishments in Chicago where it is employed it is said to yield one-third more leather than could be obtained from the same quantity of bark by the same process of tanning. The leather is also tougher, more durable, of finer texture, and capable of receiving a higher polish. The plant being an annual, can be mown and stacked like hay.

§ 4. *Food and Sanitary Matters.*

The Ventilation of Theatres.—Dr. T. HÜBNER, in the course of experiments made at St. Petersburg on the various changes of the atmosphere in the theatre, found that the temperature changed from 42° F. at the rising of the curtain to 81° and 87° at the end of the first act and the beginning of the second. He also found that the proportion of moisture increased 30 per cent., that the quantity of carbonic acid had become at the end of the second act six times as great as at the commencement of the performance, and that at the end breathing was very difficult for persons accustomed to live in the open air. *Revue Industrielle, May* 10, 1876.

Textures from Feathers.—Messrs. LECOMPTE, LEFEBRE, and ANDUZE, profess to have invented the manufacture, from feathers, of textures suitable for ladies' mantles and all other articles of clothing. The various operations for this manufacture are the following :

1. The separation of the feathers, taking care to remove the quill and barb, so as to use only the down. This operation can be performed by machinery.
2. Washing thoroughly with soap.
3. Bathing in oil.

The other operations are, with few exceptions, like those adopted for ordinary textures. The fabrics can easily be dyed. *El Porvenir de la Industria, April* 28, 1876.

White Maize Flour.—M. CHIOZZA has succeeded in completely separating the yellow oil in maize flour by the action of sulphuric acid in solution on the grain of maize. This leaves in solution an albuminous phosphate of resin, to which the hardness of maize grain is owing. The seed is not affected. The grain having been softened, is subjected to a slight pressure to separate the seed, which is reduced to flour in the ordinary way.

No one hitherto has made use of sulphuric acid to separate the seed, which, when freed from oil, represents more than 67 per cent. of the weight of the maize, and contains 78 per cent. of starch, 6 of nitrogenous substances, and only 6 of ashes, while ordinary maize flour contains, according to Payen, 28 per cent. of starch and 33 of oily matter. Hence, on account of the great quantity of starch it contains, its whiteness, and the small quantity of gluten that remains, it may be advantageously substituted for the fecula of industry. When slightly heated, it might probably take the place of barley malt. The oily residue may be used for feeding cattle or the extraction of oil. *El Porvenir de la Industria, April* 7, 1876.

Adulteration of Cigars.—A New York paper mentions that a great quantity of brown straw paper lately reached Havannah, which was to be employed in the manufacture of Havannah cigars. Straw paper impregnated with the juice of tobacco stalks is wound up with the leaf in such a way that it is often impossible to detect the adulteration. Dr. Jacobson, writing in the *Industrie Blätter*, remarks that there is no difficulty in escaping detection, if the paper be specially prepared for the purpose out of suitable raw materials. It has long been known that cigar paper soaked in a solution of soluble glass gives forth no smell of paper on being burnt. *Deutsche Industrie Zeitung, April* 13, 1876.

A Good Hermetical Closing Material.—Dr. VOGEL, of Munich, recommends paper soaked in glycerine as suitable for hermetical closing, because the glycerine always remains damp, and stops up the pores of the dry penetrable paper, so that no air can get through. *Deutsche Industrie Zeitung, April* 20, 1876.

Manufacture of Colouring Matter from Sugar.—It is known that, in order to colour liqueurs, vinegar, beer, &c., use is made of a brown substance, prepared by heating cane or grape sugar in alkalies. M. ANTHON proposes for the manufacture of this colouring substance to take 220 lbs. of starch sugar, and 7 lbs. of crystallized soda (or 4 lbs. of caustic soda), added to the sugar after complete fusion. This colour, however, does not seem suitable for colouring vinegar, which partly decomposes it. M. Anthon cautions against substituting carbonate of ammonium for the soda. *Technologiste, May* 20, 1876.

Antiseptic Paper.—In the United States, paper impregnated with carbolic acid is used to wrap up meat sent to a distance, and protect it from the influence of the atmosphere.

It is prepared by melting five parts of stearine, in which two parts of carbolic acid are well stirred. Five parts of paraffin are then added to the mixture. The whole is stirred as it cools, and applied on the paper with a brush.

§ 5. *Fuel, Heating, Illumination, &c.*

The Megalograph.—This title is given by M. G. REVOIL to a new instrument which he has invented for easily reproducing objects on a large scale. The chief merit of the invention consists in the combination of the camera clara with the microscope or telescope. The camera clara, well known to painters, especially landscape painters, is an Italian invention of the celebrated Amici, which chiefly consists in an optical combination by which the eye looks through a prism and sees reproduced on paper below the images of objects that serve to guide the point of the pencil for drawing them.

By the happy combination of such an instrument with those mentioned above, an object may be drawn, however small or distant it may be, because it is seen with the magnitude produced by the microscope or telescope. Hence the naturalist will be able to draw accurately the structure of any microscopic object, and afterwards, by substituting the kaleidoscope for the microscope, those varied and simple combinations of forms and colours may be easily reproduced which are sometimes useful to the designer, and occasion most agreeable surprises by the instantaneous transformations that are presented on the slightest movement of the tube. *El Porvenir de la Industria, May* 5, 1876.

Improvements in the Preparation of Insulating and Impermeable Compounds.—Attempts have been made to produce insulating compounds by fusing together a known mineral, such as ozokerite or its residuum after distillation, india-rubber, and gutta-percha, or some other substance of that kind; but the compounds so prepared have been found too brittle, and consequently unfit for receiving or insulating electric wires, or for other uses in which they might be liable to be bent.

An invention of Messrs. FIELD and CO. provides for the production of such compounds in a flexible condition, without subjecting the ingredients to fusion. There are two processes by which this is accomplished.

According to the first, the ingredients are amalgamated by reducing them in solvents, such as coal-tar, naphtha, or other equivalent, and perfectly mixing the solutions. According to the other, the mixture is effected by pounding the ingredients together. *Moniteur Industriel Belge, April* 20, 1876.

§ 6. *Miscellaneous.*

Fires in Russia.—From an official report, it appears that there were 25,976 fires in Russia last year, of which 3,609 were the work of incendiaries. The damages amounted to about eight millions sterling.

Exhibition in Finland.—On the 1st of July an exhibition of art, industrial manufacture, agriculture, &c., will be opened at Helsingfors, the capital of Finland. The objects that will be admitted to the exhibition are the natural or manufactured products of the country. The foreign makers of machines who have representatives in Finland will be allowed to exhibit.

The buildings of the exhibition are entirely constructed of wood. They cover an area of 60,000 square feet, or about an acre and three-eighths. The surrounding ground has been laid out in promenades, coffee-houses, &c. From Aug. 30 to Sept. 5 an agricultural congress will be held near the exhibition, which will be closed Sept. 15. This congress will comprise an exhibition of cattle and farm produce.

All necessary preparations are making for receiving foreigners. It is said the Emperor of Russia and the Grand Duke of Finland will visit the exhibition. As to the country, which is little known, it presents many attractions for the tourist; landscapes full of grandeur, wild scenery, rocky coasts deeply indented, countless islands, and inland lakes of great beauty. The Daïma canal and the Dmatra cataract, which has no rival in Europe, deserve the attention of travellers. *Moniteur Industriel Belge, May* 1, 1876.

The Limited Power of the Microscope.—Professor ABBE, of Jena, asserts that the utmost power of the microscope employed in the examination of the structure of tissues and extremely minute objects has been very nearly attained. By carrying enlargement further, occasion is given to a play of light which may completely falsify observations. This remark applies especially to the examination of certain anatomical fibres. According to Professor Abbe, who has studied the matter carefully, it is impossible to distinguish details when they are so close that the first pencil of diffracted rays does not fall on the object at the same point as the cone of non-diffracted light. *Revue Industrielle, May* 17, 1876.

Statistics of Woollen Industry.—Dr. H. F. BRACHELLI, an eminent Austrian statistical authority, gives the following particulars in his work on the States of Europe.

In Great Britain, where the spinning of carding wool and worsted is most largely developed, the number of spindles at work were, in the following years:—

	1850.	1861.	1875.
Carding Wool .	1,595,278	2,182,609	3,165,569
Worsted . .	.875,830	1,289,172	2,182,792
Total . .	2,471,108	3,471,781	5,348,361

In France, Dec. 31, 1873, there were 2,898,929 spindles (of which 2,648,036 were at work) in 1,680 factories, spread over seventy-three departments. In the German Empire the number of spindles at work in spinning woollen yarn in 1874 was about 1,200,000 for carding wool, and 450,000 for worsted. Of the latter about 180,000 are in Alsace, 110,000 in Saxony, and the remainder in Wurtemburg, Bavaria, and other states. Belgium also manufactures carding wool to a great extent for exportation, but worsted spinning is not carried on so largely.

In the Austro-Hungarian monarchy the spinning of carding wool is pursued chiefly in Moravia and Bohemia, but also in Gallicia and Hungary, with about 600,000 spindles, and worsted spinning with 80,000 in Bohemia and Lower Austria, and less extensively in Silesia and Upper Austria. In Italy there are at present about 250,000 spindles at work in spinning carding-wool, and 28,000 in spinning worsted, chiefly in Upper Italy. In Russia there were in 1871 sixty-five separate establishments for the production of woollen yarn, and many in connection with cloth mills. Weaving is also extensively carried on in private houses. The central point is Moscow, where in 1871, there were 145,240 spindles at work.

The international trade in woollen yarns for the following years amounted, in thousands of *zollercentner* (=110 $\frac{2}{11}$ lbs. avoirdupois, or about a cwt.), to—

IMPORTS.

	1871.	1872.	1873.
Austria and Hungary .	86	71.3	56.1
German Empire . .	392.8	320.7	306.7
Great Britain and Ireland .	109.9	110.1	122.2
France	21.4	33.2	31.2
Italy	3.4	2.5	3.3
Russia in Europe . .	73.5	59.9	60.7
Netherlands (including silk)	86.8	81.2	91.2
Belgium	14.3	13.1	15.2
Switzerland . . .	12.1	9.9	7.8

EXPORTS.

	1871.	1872.	1873.
Austria and Hungary. .	21.4	21.4	20.8
German Empire . .	104.8	100	92.2
Great Britain and Ireland .	397.9	361.6	316.2
France	74.5	56	57.9
Italy	.4	.1	.2
Netherlands (including silk)	54.3	45.8	45.2
Belgium	128.8	120.2	151.3
Switzerland . . .	8.3	8.7	10.1

The manufacture of woollen textile fabrics is chiefly carried on in Great Britain, France, the German Empire, Belgium, and Austria. In Great Britain and Ireland the numbers of power looms at work in the following years were:

	1850.	1861.	1872.
Carding Wool . .	9,439	21,770	57,090
Worsted . . .	32,617	43,048	82,000
Total .	12,056	64,818	139,090

In France, December 31, 1875, there were 1,408 factories in 60 departments engaged in woollen manufacture with 81,870 looms (of which 21,934 were power looms and 59,936 hand looms) at work, and 1,791 idle. In addition, there were 236 factories with 57,989 looms at work in producing mixed stuffs, 11,145 being power looms. The Departement du Nord and that of Marne contain most looms.

In Italy the manufacture of woollen textures is a subordinate branch of industry at present. In Russia, including Finland, there are about 50,000 looms at work for the production of woollen goods. Weaving is also carried on as an accessory occupation by the people in many places. The chief seat of all woollen manufacture is Moscow. In Sweden, in 1872, there were fifty-three factories for the manufacture of woollen and half woollen fabrics, the produce of which was not sufficient for home consumption. The chief seat of cloth manufacture is Norrköping. In Norway and Denmark, also, the manufacture of woollen goods is insufficient for home consumption. In the Netherlands, at Deventer and Delft, carpets are made that have

a European reputation, and also at Luxembourg the preparation of cloth forms an important branch of industry. In Belgium the manufacture of woollen goods is concentrated in the province of Lüttich, and that of worsted and mixed stuffs at Brussels and the neighbourhood.

The international trade in woollen fabrics for the following years was in marks or shillings, as follows:

IMPORTS.

	1871.	1872.	1873.
Austria and Hungary	37,306	44,366	42,562
German Empire	unknown	92,800	83,586
Great Britain and Ireland	93,068	81,066	71,040
France	62,320	79,920	47,760
Italy	43,762	44,254	42,468
Russia in Europe	32,750	46,000	41,316
Netherlands	17,626	19,352	19,638
Belgium	18,424	19,052	21,280

EXPORTS.

	1871.	1872.	1873.
Austria and Hungary	37,504	32,260	30,646
German Empire	unknown	169,966	165,492
Great Britain and Ireland	545,822	650,256	509,028
France	214,400	251,600	260,720
Italy	3,272	2,648	2,682
Russia in Europe	1,072	3,406	378
Netherlands	2,820	5,626	7,120
Belgium	30,818	35,864	31,668

Deutsche Industrie Zeitung, April 6, 1876.

A Useful Levelling Instrument.—A new and in many cases very useful levelling instrument has been recommended in the Dresden *Gewerbe-Verein*. It is constructed as follows:—Two glass tubes, standing upright on feet, and open above and below, are connected below with an india-rubber tube of any convenient length. If water is poured into one of the tubes, it will naturally rise to the same height in the other, however uneven the ground may be. When ground is to be levelled, the tubes should be set up at convenient distances, and stakes put into the ground, so as to reach the height of the water level. The more uneven the ground is, the higher the tubes must be; but the inconvenience arising from this may be in some measure alleviated by the use of stones or other supports. The chief advantage of this water level is that levelling may be performed with it even round corners.

The Importation of Wood into England during 1875.—The value of the wood imported into the United Kingdom during the year 1875 was £15,362,459 against £21,830,428 in 1874, a decrease of £6,467,969. The importation to London in 1875 was as follows:—

From	Shiploads.	Tons.
Norway	202	77,569
Sweden	399	189,005
Finland	82	31,982
Russia	363	168,103
Prussia and Germany	218	75,389
British America	193	138,134
Nova Scotia	42	19,190
United States	48	32,969
East and West Indies	13	11,697
	1,560	744,038

Writing on Glass.—M. TERQUEM has pointed out a method of writing on glass with ordinary or Indian ink. The glass is to be first gently heated at a spirit lamp or gas flame, till steam ceases to be deposited on it, up to 112° or 140° F. Then a particular varnish should be poured upon it, as is done in photographic operations with collodion. This varnish is composed of 80 grammes (51 dwts.) of alcohol at 203° F., 4 grammes (61 grains) of mastic in drops, and 8 grammes (122 grains) of pounce. The resins are dissolved by being heated in a hot water bath, the whole being in a flask corked and fastened. The solution is to be afterwards filtered.

This varnish is very hard, and becomes brilliant and completely transparent. If it is poured on the cold glass it becomes opaque and absorbs ink. Drawings may be executed upon it with common or Indian ink. Then a thin layer of gum is put upon it by dipping the glass in a very diluted solution of gum or any other non-alcoholic coating.

This process might be advantageously employed instead of labels on bottles in laboratories, and for making figures on glass, and perhaps for tracing drawings, which might thus be reproduced by photography. *Moniteur Industriel Belge, April* 20, 1876.

The Origin of the Centigrade Thermometer.—The invention of the centigrade thermometer is generally attributed to a Swedish philosopher named Calseus, but M. LAFON, the Director of the Observatory of Palais Saint-Pierre, in a recent meteorological report, gives the following account of its origin:—The first thermometer seen at Lyons was sent in February, 1737, by Dahamel, a member of the Academy of Sciences, to P. Duclos, Director of the Observatory built by the Jesuits above the college chapel. This thermometer had been constructed on the principle of Réaumur's, that is, it indicated 80° when spirit of wine was on the point of boiling,—a temperature a little below that of boiling water.

But a member of the Lyons Academy, named Christin, substituted mercury for spirit of wine, as Fahrenheit had already done in 1724, and Desauvage, of Montpellier, in 1736. Christin having poured into a tube with a bulb at the end a quantity of mercury, which might be represented by 6600 at the temperature of freezing water, found that when the tube was plunged into boiling water, the volume of the mercury increased to 6700. The mercury having thus increased 100 parts, Christin thought it natural to divide the space in the tube between the two extreme points into 100 equal parts, and said that these new divisions, though smaller than Réaumur's, would be more in harmony with the sensations produced by changes of temperature. Such was the origin of the centigrade thermometer, which was soon extensively used under the name of the Lyons thermometer. *Moniteur Industriel Belge, April* 20, 1876.

The Traffic between Dover and Calais.—The following figures, taken from official documents, show the development within the last few years of the communication between England and the Continent by way of Dover and Calais. The numbers of travellers in the following years were:—

1866	125,732
1867	199,137
1868	142,223
1869	154,859
1870	107,308
1871	116,996
1873	181,270
1874	198,656
1875	208,432

The increase in 1867 arose from the Paris Exhibition, and the decrease in 1870 and 1871 from the French and German war.

The number of passengers last year by way of Folkestone and Boulogne was 110,419, and of those who preferred the route from Newhaven to Dieppe 58,235, while only 24,265 went by the Southampton and Havre line. The total number of travellers, therefore, last year was 401,361.

Casks made of Cement.—Wooden casks in damp cellars are liable to become unfit for use before long. On this account Herr BOLLERT determined to try casks made of mortar, covered over with Portland cement. When hard enough they were filled with water, and exposed to its action for ten days in order to abstract the lime. This object was not accomplished, for in a few days it was found that the wine had lost all its acidity, and at the end of a fortnight a thick crust had formed on the sides. Good wine which was afterwards put in underwent no change for the worse, and for five years the casks have been in constant use. Fermentation and fining go on quite right. There is merely an insignificant loss of acidity, and rather a thicker crust than is usual with wooden casks.

Herr BOLLERT has for several years had no wooden casks, nor does he want any, as the work of the cellar is much simpler and better without them. The advantages of cement casks are, a great saving of room, as they can be made much larger than wooden ones, greater solidity and durability, little loss of the contents, less cellar work, because there is no formation of fungus, less dampness in the cellar, and consequently less foul air, and lastly, less expense for repairs. *Die Weinzeitung.*

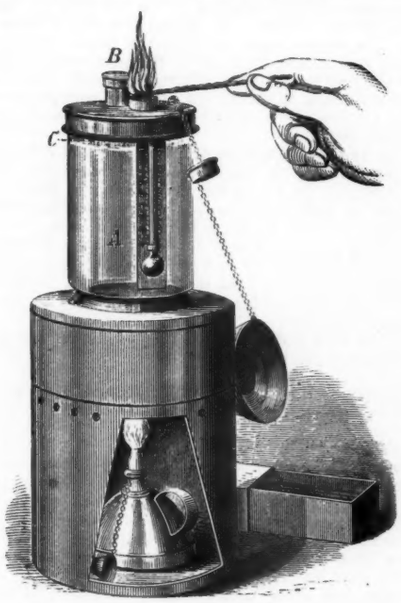
Crystallized Glycerine.—M. VAN HAMEL ROOS lately submitted to the London Chemical Society a magnificent specimen of crystallized glycerine, weighing half a hundredweight. He has found that glycerine, perfectly pure and anhydrous, crystallizes spontaneously when cooled to 26° F. and well stirred, a crystal of glycerine being put in. Moreover, when the glycerine of commerce is cooled, and a crystal of pure glycerine is put into it, this crystal soon increases, while the impurities remain in the mother liquor. This experiment may serve to ascertain the purity of commercial glycerine in manufactures which consume it largely, as, *e.g.*, that of dynamite. At present, in purchases, the use of the aerometer very often leads to errors of 50 per cent. with regard to the richness of the glycerine.

IMPROVED APPARATUS FOR TESTING ILLUMINATING OILS.

WE have so frequently called the attention of our readers to the dangers attending the use of cheap and inferior kerosene oils that to repeat the warnings is scarcely necessary here. Kerosene accidents, with their disastrous results, need not occur if the retailer or consumer of the oil who will take the trouble can, by a simple test, satisfy himself as to the safety of the same.

Any oil which will evolve inflammable vapour at so low a temperature as 100° Fah. should be as scrupulously avoided as if it were gunpowder. That temperature may easily occur in a lamp, and the vapour therein forming, mingling with the air, may readily be ignited by a chance draft blowing down the flame above. It is a safe rule not to purchase oil which will flash under 110° Fah., and it should be further understood that the greater the heat the material will endure above 110°, the greater the proportional increase in its safety and value.

In order to admit of the making of the test above referred to with ease and certainty, Mr. Pethuel Millspaugh, of Kent, Conn.,



has recently introduced a simple little apparatus which is represented in the accompanying illustration. It consists of a sheet metal chamber which receives a lamp below, and a glass vessel, A, above. The latter is formed with a contracted lower portion, so that the wider part above makes a shoulder, enabling the glass to be firmly set in the orifice over the lamp. The vessel is surmounted by a suitable cover, in which there is a filling aperture, B, and another opening, at which the test is made. To the cover is also attached a small thermometer, as shown.

The method of using the device consists in filling the glass, to the point C with the oil to be tested. The lamp is then ignited; and a lighted taper is from time to time applied to the cover orifice, as represented in the engraving, until a flash takes place, when it remains only to note the temperature of the oil as indicated by the thermometer. The tapers are shown in the small box beside the apparatus, and are sold with the latter.

When it is desired to determine the degree of heat at which the fluid actually takes fire and burns, which is commonly called the "fire test," the apparatus may be easily adapted therefor by removing the cover (though leaving the thermometer in the fluid) and touching the surface of the oil with the taper.

These tests are very easily made, and are claimed to be accurate. Sufficient oil is held in the glass vessel for a fair and satisfactory trial; and the process of heating is slow and gradual, approximating closely to the manner in which the oil is heated when it is used for domestic purposes.—*Scientific American.*

THE SPECIAL COLLECTION OF SCIENTIFIC APPARATUS AT THE SOUTH KENSINGTON MUSEUM.

THE Lords of the Committee of Council on Education have contributed a most valuable stimulus to general and technical education, in approving the proposal to form a Loan Collection of Scientific Apparatus; and the gentlemen who undertook at their request to form a committee for this special purpose, have by their zealous labour done well to have brought together in less than sixteen months this magnificent result.

In addition to the interesting relics provided at the Patent Office Museum, and now lent to this exposition—relics and specimens which have not secured general attention because of their inferiority of location—there have come from all parts of this kingdom, and from all foreign lands except America, contributions of historic interest; and from France and Germany objects of modern manufacture or rather construction, especially in chemistry, electricity, and their kindred sciences, such as could not have been obtained except at a very large expenditure, and are now furnished by the owners without cost.

That the scheme is successful is evident to any visitor; but its value has just had a memorable confirmation in the assemblage which gathered at Marlborough House on the 24th ultimo, for consultation on a plan to form a scientific library that should have its location near the buildings now in progress on the South Kensington estate for the Natural History Department. This, without doubt, will be carried through, and thereby the public will have in perpetuity not only the major part of this wonderful display, but be in a position to receive, by bequests or long loans, many other hidden relics of the past, provide a working locality for the existing fine collection of patented inventions, and thus create a nucleus for such a treasure as the world has never seen, or will ever be able to exhibit elsewhere.

The exhibition itself has received a very general notice from the daily papers, and we do not propose to repeat or to make a *résumé* of such matter. The event supplies an opportunity for an independent class of observations, interesting to those engaged in practical and scientific arts, because it connects the past and the present, and enables the rising generation of students to observe in form what they know in idea concerning the vast progress which has been made during the last half century. If they are good sons they will not, cannot, ought not, despise the works of their fathers, who at the very uttermost of disadvantages laid the foundations; they will rather search beyond and see what was. Then the present will tend to mitigate the force of depressive circumstances as they may arise in the day-by-day contentions of life, and afford in richness and plenitude the supply of hope by inspiring motives and administering strength. Then also will they, if thus affected, learn that the sorrow of to-day is the life of to-morrow; and, seeing the width and breadth, the length and depth of the ground on which they are permitted to stand, they must recognize the truth—for truth it is that can never be disregarded without peril—that upon them rests the responsibility of a trust, compared with which the legacy of a thousand acres is not to be weighed, for the life they have selected as their own is of ever-spreading and of ever-fruitful glory.

The first room we enter is marked "Educational Collections," and those we pass, reserving them for another paper.

In the second stands "Puffing Billy," George Stephenson's first work. It was employed for colliery work, and is of very primitive construction. The boiler is cased in wood; the fire-tube passes completely through, and a singular arrangement of different sized cog-wheels beneath was the method of obtaining locomotion. Close by it is the famous "Rocket," the work of the same engineer in 1825, ten years after its predecessor, and as none of our contemporaries have supplied any especial information concerning it, the following will be of interest.

The origin of the Liverpool and Manchester Railway is a very old story to the readers of engineering history. The public of those towns determined to start a connecting double line, and issued their prospectus of the company on the 29th October, 1824, in which the advantages to passengers, to trade, to traffic, to carriage of agricultural produce, and the coal transit, were exhibited most forcibly; for in all general transit of merchandize or agricultural property the people had been depending upon the canal, which 30 miles in length, did in a day what the rail at half the distance could do in two hours. The people of the two towns, moreover, were charged for carriage of coals 2*s.* per ton, and that in those days meant £100,000 a year of waste money.

They made the railway, but differed about the ***kind*** of car-

riage and the *power* to be employed. They were deluged with all sorts of speculations, from the artizan to the mathematician, and all lands sought to enter the lists, for the time was ripe. We cannot now in our enthusiastic age realize their enthusiasm. We are daring, but they were visionary. They could make the friction so slight that a silk thread would draw the carriage, and they could find power that would break the strongest cable. They demonstrated that hydrogen gas and high-pressure steam, that columns of water and columns of mercury, that a compression of atmosphere and perfect vacuums, that machines working without fire or steam, could be made to generate power at one end and give it out at the other; that carriages could be made conveying every one on his own individual railway by wheels within wheels, which would multiply without lessening power; and other extravagances.

The company had to decide whether rope or steam should be the power. They went to the Darlington engineers, and gave directions for the scientific and commercial engineers. Upon their report the committee founded the opinion that if light locomotives could be used, it would be desirable to use steam; and if that condition and the provision of the Railway Act that they *should not smoke* were complied with, they would submit a public invitation for an improved locomotive engine. The conditions were, a prize of £500; to consume its own smoke; the 6-ton engine to draw on the level 20 tons, including tender and water, at the rate of 10 miles an hour, with no more than 50 lb. pressure per in. of steam. Two safety valves the engine man could not control, and unfastened in the working, were prescribed. Engine and boiler to be on springs, and rest on six wheels, and the height from chimney-top to the ground under 15 ft. The weight with water to be under 6 tons; and the boiler, tube, cylinders, &c. to bear 150 lbs. per square inch. A mercury gauge and index rod to show 45 lbs. per square inch, and blow out at 60 lbs.

These engines were to be in, complete, on October 1st, at Liverpool. Their price as delivered must be £550, and the gauge was 4½ ft.

The tests were made. Only five came to the scratch. These were, Braithwaite and Ericsson, "The Novelty," 2¾ tons; Hackworth of Darlington, "The Sans Pareil," 4¼ tons; Robert Stephenson, "The Rocket," 4 tons 3 cwt.; Mr. Brandreth, "The Cyclopede," 3 tons, worked by a horse; and Mr. Burstall, "The Perseverance," 2 tons 17 cwt.

We all know that the "Rocket" won. As this number is interesting to engineers, let us set forth the particulars concerning the old steam-engine now to be seen in the galleries at South Kensington. "The furnace is 2 ft. wide and 3 ft. high; the boiler is 6 ft. long and 3 ft. in diameter. The furnace has an external casing, between which and the fire-place there is a space of 3 in., filled with water and communicating with the boiler. The heated air from the furnace is circulated through the boiler by means of twenty-five copper pipes of 3 in. each in diameter, terminating in the chimney. It has two safety valves, two cylinders in inclined position embracing the boiler; connecting rods to supply motion to the wheels; slide valves and two escape pipes; and also a tender for the carriage of fuel and a water-cask." The power excited admiration. It drew a load of 13 tons at the rate of 10 or 11 miles an hour, and without a load it attained a speed of 18 miles.

When the day of trial came, the "Rocket," with its load as above stated, and passengers, weighed 17 tons; the journey was 1¼ miles and return, with 120 yds. given at each end for getting up speed. The race was 20 trips, 35 miles, and it was accomplished in 3 hrs. 10 min., 11 miles an hour. Then water had to be taken in, and a second course run; this took 2 hrs. 52 min., or 12 miles an hour. She more than fulfilled the prescribed conditions, for sometimes the speed reached 20 miles an hour.

Several trials followed, and the "Rocket" came off most victoriously, running up inclined planes, although the result to us is really amusing, for a speed of 3 miles up an incline now-a-day would be absurd. The railway from Manchester to Liverpool had been completing, and on the 15th September, 1830, "the stupendous work," as it was then named, was opened in the presence of an innumerable multitude, and by every circumstance of procession, festivity, and show. Stephenson put on eight engines, Braithwaite and Ericsson, two; all the carriages had their passengers, and flags and colours. The "Northumbrian" led the way, Stephenson's engine, and the brilliancy of the scene surpassed all the powers of description then in use. Shouts of joy resounded among the thousands of spectators as they passed along, and the speed reached at one point 24 miles an hour. The "Northumbrian" stopped to allow the others to defile before the distinguished persons she had "on deck." These at one point alighted, that they might better observe what was doing, and among them was Mr. Huskisson, the distinguished member of Parliament. As the "Rocket" came by he got in the way and he was thrown down; the wheels passed over leg and thigh, fracturing them and causing his death in a few hours. The festivities instantly were suspended, but the engines went on from Rainhill to Manchester, in order that the programme of the occasion should be carried out. Mr. Huskisson was taken in twenty-five minutes a distance of fifteen miles; and thus gave a most melancholy proof of the success of a project his fine judgment approved.

But steam engines existed long before railroads for purposes of steam navigation, and a model of the earliest, that of Newcomen's (No. 1943), is close to the locomotives, and there is also (1929) a collection containing the engine, and Savory's engine, and other models. These resulted from the curious suggestions of the ingenious Marquis of Worcester. Savory's was made in 1698, and Newcomen's in 1705. This latter is the parent of all we have; the others were mere transition machines, combining the common pump with the use of steam, whereas Newcomen formed the basis on which Watt worked out his thousand contrivances, models, drawings, and plans. Newcomen was a mechanic, a kind of blacksmith and locksmith, a man of great simplicity, and a man of piety, residing at Dartmouth, in Devonshire. His leisure had ever been occupied in scientific researches, and the subject of Savory's engine pump, for draining the mines of Cornwall, attracted his attention. He conceived the idea of producing a vacuum below the piston of a steam engine, after it had been raised by the expansive force of the elastic vapour, which he effected by the injection of cold water to condense the vapour. He joined Savory in some of his patents. In twenty years Newcomen's engine was generally employed, and became the basis of the great northern development of the coal trade. The colliers there were much hindered by water collecting in the mines, and they applied to the committee in London who had the conduct of business arising from Newcomen's patent.

In 1725, Andrew Wanchope, of Edmonstone, Mid Lothian, obtained a license from the London committee, and it was described as "a patent for the engine for raising water by fire." He was was bound to erect it at his own cost; "the steam cylinder is not to exceed 9 ft. in length, and 28 in. in diameter." And he covenanted to pay £80 a year for eight years for the license. The committee agreed to provide the cylinder, regulator, and other brass work at the cost of the proprietor. And curious enough to note, "*the workmen who erected it were all from somewhere beyond London.*"

But at this time of day practical men will be interested in Mr. Ball's account of the bill of particulars:—

	£	s.	d.
A cylinder, 20 in. diameter, with workmanship, carriage to London, and all other charges	250	0	0
A piston	9	10	0
A brass barrel, 7 ft. long	17	10	0
A brass bucket and clack	0	13	0
Paid for elm pump pipes at London	53	4	6
Two cast metal barrels, 9 ft. long, 9 ft. diameter, and expenses connected with them	41	16	6
Two brass buckets and two clacks, 9 in. diameter, a brass regulator and injection cock, and other cocks, sinking vouls, injection caps, snuffing vouls, and feeding vouls	35	5	0
One jack for the wig	0	12	0
Plates and rivet iron, for making the boiler	75	10	0
Six Swedish iron plates	6	3	0
Plumber's bill for lead, and a lead top for the boiler, with sheet lead and lead pipes	78	10	6
Solder	15	10	0
Timber bought in Yorkshire for the engine, with carriage by land and water, and freight to Newcastle	82	16	0
44 cwt. 1 qr. 14 lbs. of chains, screw-work, and all other iron-work about the engine, except the hoops of the pumps, at 5*d.* per lb.	103	10	10
Ropes	19	16	0
Cast metal bars for the furnace	16	14	0
A hand-screw	1	17	0
Two brass codds for the regulator beam	5	14	0
Plank for the plug-holes in the pumps	2	10	6
Leather	18	13	0
Iron hoops for the pumps, with screw-bolts and plates for ditto, 18 cwt. at 4*d.* per lb.	32	12	0
Two copper pipes	0	8	0
Carriage of the materials from London and Newcastle to Scotland	22	2	0

John Potter, pains of going and coming upon account of Edmonstone engine . .	£50 0 0
Travelling expenses of the workmen, and their wages	52 18 0
	£893 15 10
Six workmen were sent from England. They had 15*s.* a week as wages, besides their expenses paid. Mr. John Potter, engineer, furbished this bill, and claimed many items for carriage and such matters, by which it ran up to more, by . .	113 15 6
	£1,007 11 4

J. and A. Potter, of Durham, engaged to make it efficient for raising water by pumps of 7 and 9 in. bore. The engine was of 7 and 11 horse power. All building costs they were to pay out, and in return have 10 per cent. out of the price and profit of the first coals raised; Abraham to receive £200 a year for "his pains," and for keeping workmen to attend the engine, and for wear and tear in repairing; coals to be gratis, and time allowed for repairs; accidents to be paid out of mining profits; and after all costs were paid the engineers to have a half of the nett profit. In the event of failure to draw off the water, the engineers to take back their materials, and be allowed for expenses.

The Edmonstone Colliery was useless until this step had been taken, and succeeded afterwards.

We pass on to notice a patent steam engine made for Patrick Miller, Esq., as one of the most interesting articles illustrative of marine engines.

Respecting this let it be noted that Miller, in 1787, published a description and drawings of a triple vessel, moved with wheels, and also gave particulars of the power and advantages of his invention. In that he suggested that steam power might be employed to produce rapidity in the ship's career. He did not make this remark without forethought. He had experimented on the comparative velocity of his double and triple vessels, when propelled by sails or by oars, and had watched the strife of competition as to speed, and reached the conclusion that the human arm must be aided by mechanical contrivances. He tried to utilize horses and to regulate winds, but came to the conclusion that steam was at once potent, certain, and manageable.

This man was one of a race of whom we have not many specimens, and really less reproductions. In every improvement scheme involving mechanics he was eager in promotion, and he spent large sums in experiments about naval and artillery construction. These led him to the making his double and triple vessels, moved by wheels placed in proper situations. He had in his family a tutor for his children, James Taylor, who knew somewhat about the steam engine, and had assisted Mr. Miller in his experiments on the water.

A contest for speed occurred one day at Leith, and Taylor exclaimed, "We only want steam to beat them;" in fact, both were going only about five miles an hour. Miller did not forget it, and hence made the allusion above noted.

After this expression, he, being ever a practical man, began experimenting. He made a small handsome double vessel with wheels—a pleasure boat, on his own lake at Dalswinton; and in this little vessel he determined, if possible, to apply, or rather to test, the capacities of the power produceable from steam. It happened that James Taylor had as a boy a school-fellow, William Symington, who just then was making a name by his contrivances for applying steam force to wheel carriages. Mr. Patrick Miller, of course, was informed of this, and went to Edinburgh to see the model at the house of Mr. Gilbert Meason. He forthwith engaged Symington to superintend the construction of a small steam engine for a boat. In the autumn, that engine, which had brass cylinders of 4 in. diameter, was fixed in the pleasure boat on Dalswinton Loch. Nothing could be more gratifying or complete than the success of this first trial. For several weeks Patrick Miller and his visitors were delighted, and he *saw the power* of steam. When winter drew on, he removed the apparatus, and placed it in his library at Dalswinton, where it was reverenced among his other relics by his family long after, as a monument of the earliest instance of navigation by steam.

This patent steam engine is numbered in the Catalogue 2150, and the authorities add that "the castings were executed in brass by George Watt, founder, Low Calton, Edinburgh, 1788," and that this first experiment succeeded in equalling oar and wind force by being sure of five miles an hour. The letter of Patrick Miller is affixed to the case: it is an order for its execution under Symington's direction. The lender in this case, as in a great number, is Bennet Woodcroft, Esq., F.R.S.

In our notice of the Life of Sir Charles Fox last month, it was stated that he inherited by the power of his genius the business of Mr. Bramah, at Birmingham, from whose establishment the first hydraulic press emanated. This is one of the South Kensington treasures. He also invented the rotary steam engine. Bramah's life is little known. His father was a small farmer at Stainsborough, in Yorkshire, and in his early youth he followed his father's occupation. In his leisure time he resorted to the blacksmith's shop of the village, because the owner had a fondness for ingenious pursuits. By an accident he was lamed, and unfit for farming, and at sixteen his father apprenticed him to a carpenter and joiner. At the end of the term he went to London to find work, and soon became a master in that trade. During his apprenticeship, and before, he had shown mechanical skill in making two violoncellos, and in making a fiddle out of one block of wood, with tools made at the forge above named by another young fellow, who came to London, and became Bramah's principal workman. Bramah prospered in London, and soon became known as a man of fine invention and ingenuity. In 1784 he brought out his world-famed lock—a mechanism never surpassed for its safety, durability, elegance, and simplicity. He had read in Grecian story about the pressure of fluids, and had studied hydrostatic science; and it was his happy fortune to make that wonder of mechanical art—the hydraulic press—by which a child's arm can heave a tree from its rooted rest, and crush bars of iron as one would break sticks: a machine so familiar as to be unnoticed, but in reality as serviceable as a steam engine. This first hydraulic press was patented in 1795, and is exhibited (No. 1994) among other kindred inventions.

Bramah also made the beer machine, by which all our publicans now can draw from any distance what before they had to fetch. He also made at Woolwich Arsenal the planing machine, and another for turning spherical surfaces, either convex or concave. He set out the machinery for making paper of any size; for printing by a roller containing a shifting alphabet, after the fashion of our numerical presses. The pen-making machine, the machine for making main-pipes, sawing machines, improvements in the construction of bridges, canal locks, wheel carriages, and many other things, are well known, and testify to the greatness of his genius and the excellence of his character.

Close to this is placed No. 1936, an original model of Trevithick's locomotive engine, which was patented in 1802. This curious work was set in motion two years after the patent was granted, on the Merthyr Tydvil Railroad, when it drew as many carriages as carried ten tons of iron, at the rate of five miles an hour; but it did not succeed, owing to the defective knowledge of mechanics then universal. His engine remains a credit to himself and an honour to his country, for it was the constant study of all who followed. He could not get the wheels to bite. The power of locomotion did not suffice without securing the adhesion of the wheels, and this remained undiscovered until the knowledge of high-pressure steam dawned upon his mind and that of others some time afterwards. His wheels were toothed wheels, working into toothed racks, as in the "Puffing Billy." Stephenson improved upon it by making a new one in 1814, which was tried at Killingworth, and with 20 tons weight it covered four miles in an hour. The improvement he made consisted in using two cylinders, but retaining the toothed wheels. But when the long-discussed question of high pressure became settled by experiment, the way was open for the great makers to enter another competition, which resulted in the famous Liverpool and Manchester race, and settled many problems until then under rather angry discussion.

But the student will find the greater amount of instruction in a careful inspection of the very large series of models executed by James Watt. Had Watt done nothing more than these he would be esteemed for his genius, and worthy of the everlasting affection of mankind; and their loan by Mr. Gilbert Hamilton (of Birmingham) is one of the best contributions to the exhibition. It is futile to attempt their enumeration, or description, or variety. They concern the whole range of mechanical powers, and as such, require more than one day's honest, painstaking observation. One doubts whether their suggestiveness can ever be exhausted. They display genius—palpable and unmistakable genius. Watt could not only absorb all, but he was the hardest of students; and whether it were philosophy or mechanics or navigation, the whole realm of matter and of mind seemed to be so familiar to his perception that nothing but the limitations of time, life, and circumstance could give any embarrassment. There is not so much to look at as there is to study; and not to study merely to excite in one's self a pride in the power and resources of the human intellect, but to lead every one to make the very best use of every scrap of knowledge, of every mental and moral faculty, and every atom of time.

The set of eight models of the block-making machinery made by Marc Isambert Brunel recalls to us the genius whose inventions have made his name conspicuous and enduring. He was

born in Normandy, the son of a long race of agriculturists. Intended for the church, he went to Rouen for education, but mathematics and the physical sciences absorbed all his mind, and led his father to remove him to the naval profession. In his voyages to the West Indies he produced, at the age of fifteen, a sextant of his own manufacture, and used it daily. On returning to France in 1792 the Revolution had broken out, and he being a royalist, fled to America, where he became civil engineer and architect. His first survey was at Lake Erie; then in canal forming; and at New York he accepted an engagement to erect an arsenal and foundry, and here his versatile powers had scope in devising new machines for this purpose. He designed the Bowery Theatre, and also a very handsome House of Assembly. The one he superintended, but the other was deemed too ornate for a republic.

This block-making machinery had long occupied his attention, and he determined on seeking in England a larger scope for his powers, especially as he had here influential friends. Earl Spencer had long been his friend and patron, and through his influence the red-tape obstructiveness inherent to the Admiralty gave way, and the machinery for caulking, scoring, rounding, drilling, shaping, facing or lathe-work, boring, cornering, sawing, and morticing, was constructed under his superintendence and plans by Mr. Maudslay; and there at Portsmouth Dockyard they continue to this day. "Where fifty men were necessary to complete the shells of blocks previously, four are all now required; and to prepare the shears, six men can now do the work of sixty. Thus sixty men accomplish with uniformity, celerity, and ease what formerly required the uncertain labour of one hundred and ten." This invention is all the more deserving the student's reflection, from the circumstance that for these various machines Brunel had also to construct tools. Here is a great claim on the gratitude and admiration of all constructors of machinery and all workers in metal, for in that department will be found all the types and examples of modern self-acting tools, without the aid of which modern appliances could not be accurately produced. The drilling, slotting, and shaping machines, the eccentric chuck, and the slide-rest with the worm-wheel motion, are all to be found in his machine.

This machinery he finished in 1806, and it resulted in a national saving of £24,000, two-thirds of which were awarded to Brunel, who soon after accepted the Government order to erect improved saw-mills at Chatham and Woolwich. Many exquisite inventions followed, such as his machine for using several pens for producing simultaneously copies of manuscript, a portable copying machine, a pill-box making machine, and (a much more important one) the circular saw for veneers, by which the use of veneers became almost universal. He invented the machine for making shoes, but it lay by for years unused. Then the steam-tug followed, the experiments for which he paid chiefly himself, for the Admiralty counted it a chimera. The steam engine was a favourite study, and many were his suggestions; and, finally, we must recognize him to have been the introducer of the invention of an atmospheric gas engine. This project cost him much care and money, and in his increasing years he accepted the popular indifference, and let the whole lay by unused until circumstances might tempt capitalists and manufacturers to take up his thoughts, and give them form and substance. Suspension-bridges and the Thames Tunnel lastly absorbed his active brain, and in that work he was aided by his son, who inherited his father's spirit and renown.

Then there is another work of Brunel's (2021), a machine for winding cotton into balls, which he invented in 1802, a machine that led to the introduction of sewing cotton and made it universal, for before that time sewing was generally done with thread and only sometimes cotton, but always in skeins. The advantage is apparent.

Our last notice here must be that of the atmospheric gas engine (Otto Langen and Crossley's joint patents), actuated by the vacuum resulting from the explosion of common coal gas and air.

"In this engine, the piston is not, as is usual, connected with the shaft on both up and down stroke, but on down stroke only. It is thus at liberty to fly up freely from the force of the explosion, which takes place at the bottom only, and by driving the piston before it empties the cylinder of air through its open upper end. The return of the air on the down stroke yields the driving power, and turns the shaft by means of a friction clutch, to which the piston is geared by the rack. The vacuum beneath the piston is equal to about 11 lbs. per square inch for the greater part of the down stroke. The governor does not act, as is usual, by increasing or decreasing the power of each stroke, but by varying the number of strokes, each being of the same power. This is done without materially changing the speed of the shaft. Three or four explosions per minute are generally sufficient to turn the engine itself, and as a maximum of thirty to thirty-five may be made, there is a balance of, say, from twenty-six to thirty-two strokes or explosions per minute left to be applied to useful work under the regulation of the governor. As this engine can be started and stopped at a moment's notice, giving full power at once, and is free from the risks of a boiler explosion, it is peculiarly suited for use as a motor in a laboratory. The consumption of gas is seldom over 2*s.* 6*d.* worth per week for a one-horse-power engine. The engine as here exhibited contains many quite recent and very important improvements."

Here we see Brunel developed. And the project is one of immense importance. We are quite aware that many a failure has been made, but the truth is gradually but surely dawning, that in the common atmosphere we possess forces, both for the purposes of power and light, of which we have only the least intelligent idea.

The models, machines, and objects in this section of applied mechanics number 470. We have only noticed the ancient ones, and of these only a selection, but there is a wealth for engineering minds which is past all estimation.

We purpose resuming the subject in the next number.

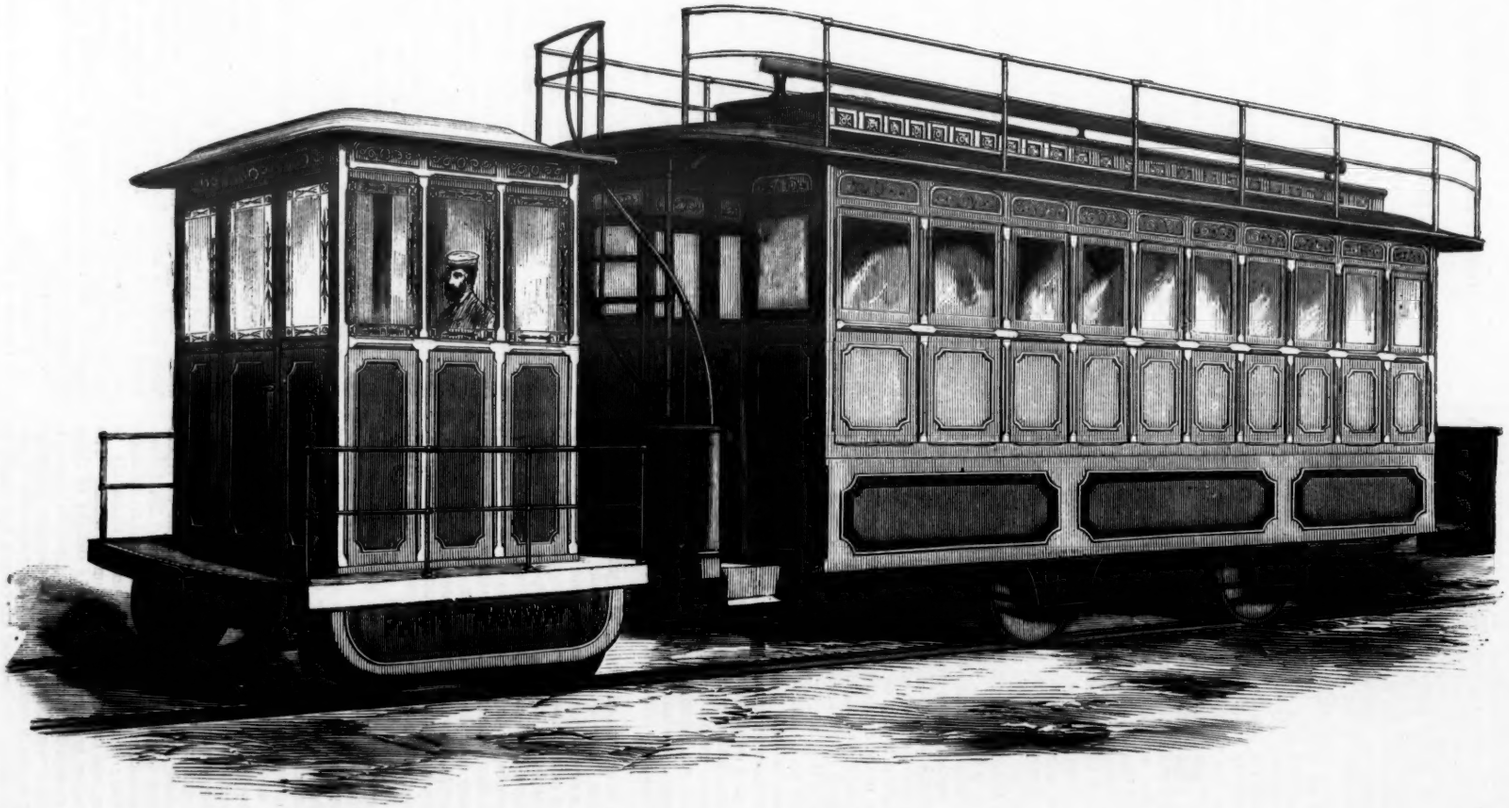
PATENT STEAM TRAM-CAR ENGINE,

By Messrs. Merryweather and Sons, London.

MUCH bitter dispute has arisen in England, in former times, concerning the invention of applying steam to common road travelling; but as Hancock, Gurney, and Dr. Church all failed to overcome the difficulties, and the land has become a network of railroads, any disquisition on the subject could only interest those who are merely curious. No practical result can possibly follow. Hancock was unlucky in his experiments, which we remember very well; Gurney could not persuade the world that he was the inventor at all; and Dr. Church occupied a place in the history that is of no moment to us of the present generation.

The subject, however, is interesting, because of the public necessities. As we have left off the pack-horse, taken to the tumbril, and left that for the stage, and that has had to make way for the omnibus and the railway, so have we found that for suburban locomotion and for town travelling we must have some changes made in the great lines of traffic, because the very pavements get too full for the public accommodation. Hence the introduction of the tramway. This, like all its predecessors, has encountered objections, some of which were reasonable and some the result of mere prejudice. Tramways, as first made, were very dangerous tenants of the highway. Their raised rail was fatal; hence, where the experiment could be made—and then the most stringent conditions were imposed—they failed, and had to be removed. But the idea contained too much of public utility to be ignored. As in all such incidents, there were many remedies and many broken hopes. Especially do we remember a Mr. Curtis, whose quiet manners had to contend with the unscrupulous Mr. Train; he had the sunken tram, but he had not the tact of our American adventurer. Both came to grief from different causes, but the public determined that the tram should be tested, provided the sunken form could find capitalists to undertake its construction. That has been done; and now the northern, eastern, southern, and south-western outlets of the town have their tram service; which is not permitted to come into the centre, and probably never will, for it is not desirable, and would in the growth of things become more undesirable. But anyone must know that with every facility which iron rails can supply to locomotion, there is something unpleasant in the recollection that two animals are drawing a car of no slight weight, burdened with forty human beings, and liable to be pulled up and started again five-and-twenty times in a journey of as many minutes. The wear and tear of horse-flesh is one thing, but the sympathy of man for his useful helper is a greater; and every right-minded person would be gratified if a change could be made, relieving the animal without augmenting the cost of an establishment, and having the advantage of increasing the general comfort and convenience of life.

The introduction of their patent steam tram-car engine by Messrs. Merryweather into Paris last December, began a new



PATENT STEAM TRAM-CAR ENGINE.

era in this phase of public service, and the experiment then made has been ratified and adopted. At the present time there is a regular service by these engines. The *Times* correspondent described the trial trip, made on December 1st, in the presence of M. Aphland, the director of works, and many members of the Municipal Council, beside other celebrated individuals. The line runs from St.-Germain-des-Prés to the Porte de Chatillon, a distance of 2¾ miles, and the car, containing forty people, was drawn by the engine in sixteen minutes, or about 8½ miles per hour. On arriving at the Porte de Chatillon, the engine was reversed, and made the return journey at between 9½ and 10 miles an hour. The engine, which is a vertical locomotive, is enclosed in a frame-work exactly like a portion of an ordinary tramway car, having a small chimney. This chimney carries off the smoke, which is really almost imperceptible. The roadway had not been cleared. In that quarter of an hour the car met riding horses, and horses in all sorts of vehicles, cabs, carriages, and waggons, but caused no alarm or tremor to any. These animals certainly looked, says the observer, as if they would have liked to be relieved from drawing burdens, but that was all. There is a special advantage in the construction of this engine, which commends it to all who have any care for animal relief, in that it stops very quickly. Five feet is quite enough between brake and stand-still. And then upon the sharp curvature of the Chatillon Road, caused by the rails being laid in order to avoid a gutter, where danger was even expected by many travellers, the speed was not slackened nor was there any jar. So at the corner of the Rue de Rennes, where the road is almost an angle, the same speed and the same safety ensued; and in one place, where the laziness or obstinacy of a coachman delayed the train by blocking the line, the pull-up was all but instantaneous—much quicker than it could possibly be had horses been employed.

The part of Paris thus traversed is a populous one, and a great crowd assembled at the terminus to cheer and congratulate the promoters of the enterprise. The government then felt, what they have since proved, their entire satisfaction at the result. It is believed in France that the system can be applied to ordinary roads, if they are well made and tolerably level. If so, there will follow an enormous saving to individuals in their daily expenses and in their prosecution of trade. Its cost is about a shilling an hour for coals; it is worked by a driver and stoker at say £3 3s. a week—that is to say, a total of 16s. per day against £2 10s., which is the cost of horse supply and all its attendant charges. If this be the beginning, we may look for improvement; and shall doubtless see that the Lambeth and Long Acre engineers, so famous for fire-engines, are able to render equally valuable protection against the exigence of travel.

In brief, there is an annual saving of £300 in the working charges of each car. The speed could easily be increased in open country. Its reverse journey requires no change of horses and the attendant delay; and of course, there is not the least impediment to attaching a parcels box to every train, thereby giving country people equal convenience to that enjoyed by their friends who happen to reside near a railway station. Further, it makes no noise, throws out no smoke or steam, can never explode, and is entirely independent of its car, whether it be merchandize, persons, or agricultural produce and supply.

For small requirements there is a construction combining car and engine, so that the most isolated of places can obtain accommodation by its means. A village could afford to have one, and two or three combined would make a good speculation for the provincial man of enterprise.

Just as the Chinese have awakened to the advantages and pleasure of locomotion, and started their first line of railway travelling amid circumstances of great glee and wonderful surprise, we read the report of the adoption of Messrs. Merryweather's patent steam tram-car engine on the Dewsbury, Birstal, and Batley tramway line in Yorkshire, by way of experiment. The engine was attached to an ordinary car, and it worked the regular traffic in turn with the horse-cars, giving every satisfaction and causing no inconvenience. The absence of smoke, steam, and noise will compel Parliament to repeal the act they passed in the days of Hancock and his fellow-inventors, which prohibited the use of steam engines on common roads; for now there is no longer a provincial monopoly to defend such a law, and no reason to urge on its behalf. The days of stage coaches are gone, save for the delight of those who have leisure to love the memory of very agreeable journeys, or what is called "the good old times;" and the temper of the age is bent on giving to every enterprise a fair opportunity of exhibiting its public utility, just because experience has taught us that any thing or thought which enhances the general comfort, is in its own nature sure to gather around it the elements and power of success.

Engineering, Building, &c.

ABSTRACTS FROM FOREIGN PERIODICALS.

§ 1. *Engineering.*

COMPARATIVE Cost of Tunnels in all Countries.—1. England.—The three principal tunnels made in England within the last few years are those of Kilsby, Saltwood, and Bletchingley. The piercing of Kilsby tunnel was particularly difficult to execute, because there was a bank of moving sand in which all structures were swallowed up. For a long time all methods of exhaustion were ineffectual. At length, however, the sand, which gave out 1760 gallons of water a minute, was exhausted. For this special work it was necessary to employ 1,200 men, 200 horses, and thirteen steam-engines, working incessantly night and day. The cost per kilometre (1,093 yards) of the Kilsby tunnel was thus raised to £176,000. The Saltwood tunnel cost £133,200 per kilometre. The Bletchingley tunnel cost only £80,000 per kilometre.

2. France.—In France the Terre-Noire tunnel on the Paris, Lyons, and Mediterranean line, cost only £64,000 per kilometre, and the Batignolles, near Paris, £92,000 per kilometre.

3. Belgium.—The Braine-le-Comte tunnel cost £46,600 per kilometre, and the Liége and Verviers tunnels, £50,600 per kilometre.

4. Switzerland.—The Hauenstein tunnel between Basle and Berne required difficult operations, and cost £88,000 per kilometre.

5. America.—The Hoosac tunnel in Massachusetts, which penetrated hard rocks of quartz and mica, cost £220,000 per kilometre, though, on account of the hardness of the rocks, facing could be dispensed with along a great part of its course.

6. New Zealand.—The Moorhouse tunnel, made by the government through deposits of lava, cost £76,000 per kilometre.

7. Mont Cenis tunnel, executed with all the improvements that could be devised for this special work by the most eminent engineers of the time, cost £204,960 per kilometre.

8. Saint Gothard tunnel was expected to be completed for £2,000,000 sterling, but this estimate has already been far exceeded, and the tunnel, which has not been carried so far as 15 kilometres, has cost £6,080,000, or more than £400,000 per kilometre. Judging from this fact, it is thought likely that the tunnel across the English Channel would cost something like £2,000,000,000 sterling. *Technologiste.*

Fixed and Portable Forges.—M. CORDIER has made some improvements in forges, which consist in the heating of the air that comes under the combustible, and the cooling of the plate of the twyer. The apparatus employed for this purpose is composed of a tank in the form of a reservoir turned upside down, placed directly under the furnace. This tank is closed in the lower part by a lid, and filled with water, which on being heated by contact with the furnace, absorbs the heat of the latter, at the same time cooling the plate of the twyer, and afterwards imparts this heat to the cold air, which passes through the twyer placed in the centre of the tank. The object of the cooling of the twyer is to prevent the scoriæ and dross produced by the coal from sticking to the twyer and stopping it up. *Moniteur Industriel Belge, May* 1, 1876.

§ 2. *Building, Decoration, &c.*

Improvement of Cement.—M. DUCOURNAU has proposed a method of improving all kinds of cement and mortar, so as to prevent the cracking of structures built with these materials, and at the same time increase the hardness and resistance. The aggregate incorporated in the cement has for its basis acetic or any other suitable acid, which is used in the liquid or solid state. The liquid aggregate is composed of acetic acid diluted with water, in proportions varying according to the product to be improved. This aggregate is especially employed for the manufacture of artificial stone. The solid aggregate is composed of the following ingredients:—

1. Acetic acid.
2. Powdered flint.
3. Grains of flint, very fine, passing through the 30 sieve, and remaining on the 50 sieve. In this way a dry powder is obtained, capable of being kept a long time, and always ready for use when wanted. *Moniteur Industriel Belge, May* 1, 1876.

Importation of Japanese Bricks.—Bricks have for some time been exported from Japan to America, but being there subject to a duty of 20 per cent., they have not yielded a sufficient profit, and the trade has consequently been limited. At the end of April a cargo of them from Japan reached London, and were immediately bought up by a few contractors and builders. In consequence of the success of the venture, orders were given for further supplies. It is stated that the bricks can be made of any size, shape, or colour, and are much harder than English ones. There is a variety of patterns well suited for ornamental facing.

THE WHITWORTH MEASURING MACHINE.[1]

THE two great elements in mechanics are the power of measurement and the true plane.

The measuring machines which I have constructed are based upon the production of the true plane.

Measures of length are obtained either by line or end measurement.

The English standard yard is represented by two lines drawn across two gold studs sunk in a bronze bar about 38 inches long, the temperature being at 62° Fah.

There is an insurmountable difficulty in converting line measure to end measure, and therefore it is most desirable for all standards of linear measure to be end measure.

Line measure depends on sight aided by magnifying glasses; but the accuracy of end measure is due to the sense of touch, and the delicacy of that sense is indicated by means of a mechanical multiplier.

In the case of the workshop measuring machine, the divisions on the micrometer wheel represent 10,000ths of an inch. The screw has 20 threads to an inch, and the wheel is divided into 500, which multiplied by 20 gives for each division the 10,000th of an inch.

We find in practice that the movement of the fourth part of a division, being the 40,000th of an inch, is distinctly felt and gauged. In the case of the millionth machine, we introduce a feeling piece between one end of the bar to be measured and one end of the machine, and the movement of the micrometer wheel through one division, which is the millionth of an inch, is sufficient to cause the feeling piece to be suspended or to fall by its gravity.

The screw in the machine has 20 threads, which number multiplied by 200—the number of teeth in the screw wheel—gives for one turn of the micrometer wheel the 4,000th of an inch, which multiplied by 250—the number of divisions on the micrometer wheel—gives for each division one-millionth of an inch. The sides of this feeling piece are true planes parallel to each other, and the ends both of the bars and the machine are true planes parallel to each other and at right angles to the axis of the bar; thus four true planes act in concert. In practice we find that the temperature of the body exercises an important influence when dealing with such minute differences, and, practically, it is impossible to handle the pieces of metal without raising the temperature beyond 62°. I am of opinion that the proper temperature should be approaching that of the human body, and I propose that 85° Fah. should be adopted, and that the standards and measuring appliances should be made and kept in a room at a uniform temperature of 85° Fahr.

In many workshops we hear the workmen speak in such vague terms as a bare sixteenth or full thirty-second, but minute and accurate measurement requires to be expressed in decimals of an inch.

In 1857, when President of the Institution of Mechanical Engineers, I read a paper on standard decimal measures of length, and I am happy to say that since that period the decimal system has been introduced to a certain extent in many engineers' works, but it is still far from being universal.

In the manufacture of our standard gauges, the workmen measure to the $\frac{1}{10000}$th of an inch, and these measures are as familiar and appreciable as those of larger dimensions.

As an illustration of the importance of very small differences of size, I have here cylindrical standards with a difference of the ten-thousandth of an inch. It is therefore obvious that a difference of $\frac{1}{10000}$th of an inch is an appreciable and important quantity.

It will be at once conceded that the only scale of measurement which can be used for such small differences must be a decimal one.

For many years the decimal system has been in use at our works, taking the inch as the unit, and the workmen think and speak in tenths, hundredths, and thousandths of an inch.

It is of great importance to the manufacturer to have the means of referring to an accurate fixed measure, as it will enable him, at any time, to reproduce a facsimile of what he has once made, and so preserve a system of sizes of the fitting parts unaltered.

The great value of the workshop measuring machine is making difference gauges.

Every external diameter having to work in an internal diameter should have a certain difference of size; and close observation and experience can alone determine what this difference of size ought to be.

Take, for instance, a railway axle; if the bearing in which it has to work be too small the heating of the axle by rapid rotation will be the consequence; if, on the other hand, the bearing be too large, it will be sooner worn out.

It is therefore most important when rapid revolutions and great strains have to be undergone that the proper difference of size, when once ascertained by experience, should be strictly adhered to.

In the manufacture of axles there should be two gauges used, the axle being made to the standard gauge and the bearing bored out to fit a difference gauge, which has to be as much larger as experience has found to be necessary, according to the conditions under which the axle has to work. Hence every manufacturer should be in a position to manufacture his own difference gauges.

Fifty years ago the thousands of spindles in a cotton factory had each to be separately fitted into the bolster in which it had to work. At the present time all these spindles are made to gauge, and are interchangeable.

It cannot be impressed too forcibly, both upon the student in mechanics and upon the workman, that accuracy of measurement is essential for good and efficient workmanship, and that it tends to economy in all branches of manufacture, so as to have the parts interchangeable.

[1] Paper on *Measurement*, read at the Conference of the Exhibition of Scientific Instruments, at South Kensington, by Sir Joseph Whitworth, Bart., D.C.L., F.R.S., &c., May 17, 1876.

Practical Literature.

LETTERS FROM RUSSIA IN 1875.[1]

THE title of this book conveys but a very inadequate idea of its contents. It is, in reality, a comparison of the merits of certain methods of Russian iron-ship-building with those which were adopted by our own Government in direct opposition to Mr. Reed's well-known views.

The circumstances under which Mr. Reed's valuable co-operation in our naval defences was practically lost to this country—which loss was undoubtedly Russia's gain—are too well known to need particularizing here. And although we have no doubt that among the fleets which are at this moment congregating in the Mediterranean our own will compare favourably with that which includes the "Novgorod" and the "Admiral Popoff," yet we cannot but consider the policy to which we have referred as an unwise one. We are glad to see, however, from this interesting little volume—we could have wished it were twice the size—that we are in no way deprived of the benefit of his opinions and advice.

It is of course impossible, within the limits of so short a notice, to reproduce the conclusions arrived at by our author with respect to the comparative merits of circular ironclads and those which they were designed to supersede, nor to follow the arguments by which he arrived at them; but his decision is so strongly in their favour, and his opportunities of observing their behaviour so complete, that we cannot but accept his view of their superiority.

A special interest attaches to this particular subject at the present juncture, when the European powers are concentrating their fleets in the Mediterranean; for should the present complications in the East result in what we all hope may not be—war—there is no doubt that the greatest struggle will be on the

[1] *Letters from Russia in* 1875. By E. J. Reed, C.B., M.P., &c London: John Murray, 1876.

sea. Then, perhaps, some of these vexed questions may be set at rest.

Our attention has been, therefore, naturally turned to this special feature of these letters, which, however, contain much of interest besides. Mr. Reed had especial opportunities of inspecting the Government works in Russia, and he bears testimony to the keenness and sagacity with which the Russian authorities adopt every improvement in the design and manufacture of their engineering works, as well as of their weapons of defence; while his descriptions of the places visited are written in a pleasant and chatty style, which renders his little book most pleasant as well as instructive reading.

We are, therefore, glad that he has been induced to reprint these letters, which were written for and published in "The Times" newspaper, and we can assure him that whatever of attention they may have gained by their first appearance in that journal, they would, under any circumstances, have been well worth preserving in their present more permanent shape.

BRITISH TRADE; OR, CERTAIN CONDITIONS OF OUR NATIONAL PROSPERITY.[1]

AT a moment of such almost universal commercial depression as the present, a work with such a title as the one before us cannot fail to arrest our attention, and we have given to it a very careful perusal, in the hope of finding, not only an explanation of the true causes of the present state of affairs, but some hints as to the best method of remedying it; and we think, some justification of our anticipations is given by the language of the preface, in which our author states his conviction that he has "caught some ideas bearing on our national condition, such as are needed to remedy it, and that feeling sure that the diffusion of these ideas will go far to give light and guidance to various classes of minds," he is "constrained to communicate his thoughts to all who may be disposed" to read them. He goes on to "confess to great indifference as to what may be thought of the book as such," and concludes with a prayer that his "humble efforts may be used under Providence for the good and comfort of our now sorely tried fellow-countrymen."

But our anticipations have been disappointed; whenever he is not metaphysical and speculative, his observations are commonplace and his suggestions to a large extent unpractical; while his views are unfolded with so much circumlocution as to make it difficult to understand what he would be driving at. Nothing is easier than to deplore the opposition which exists between employer and employed and the suspicion with which they regard each other, or to air pet theories about labour which is useful to the country and that which is not. But what we need is, some practical suggestion for Reform; certainly, we are treated on almost every page to some remarks upon the evils of the "narcotization of the thinking faculties" by means of tobacco and liquor, on the part of masters and men alike; but widespread as the evils of drunkenness are, we cannot believe that were England to be transformed into a nation of sober men to-morrow the present state of things would be removed, although it is needless to say that we are certain this would be a great change for the better.

Self-evident propositions and an unlimited number of axiomatic statements can of course be amassed as material for a book, but such a book can hardly be considered of any value as offering a solution of the difficulties which this great subject of British Trade presents. Of course, as our author says, in his chapter on "Freedom of Contract," "It will ever be true that no man ought to be free to contract so as to overreach his neighbour," but until we all arrive at that happy state of mind which our author evidently desires should be, in which if one smite us on one cheek we turn to him the other also, there will always be a tendency to this overreaching; and what we should like to have seen is, some practical proposal by which these and other infirmities to which humanity is liable may be efficiently held in check.

We must, however, in concluding this notice, do our author the justice of saying that his book is a complete summary of the evils that exist in our commercial relations, and that the charges of wrong are brought with fairness against each side alike; but we can find in it no practical utility in settling the questions in dispute or remedying the "present ills that be."

[1] *British Trade; or Certain Conditions of our National Prosperity.* By Professor Kirk, Edinburgh, Author of "Social Politics," &c. London: Hamilton, Adams, and Co. 1875.

FIRST HINTS ON RIFLE-SHOOTING.[1]

MR. HUMPHREY is a Queen's Prize man, and may therefore be considered an authority upon the subject of which he has written in the little book before us. It consists of "a collection of precepts that may warn beginners against some of the mistakes which commonly retard their progress." Considerable experience in "coaching" the members of the corps in which the author has served, an employment which has always been his interest and occasionally his duty, has shown him that in many cases the young rifle shot needs but telling to enable him to rectify his mistakes, and the most common ones into which they are likely to fall are here pointed out, and the way of avoiding them explained. There is no doubt that beginners will find it of use, and well worth the small coin with which it can be purchased.

MASTER AND WORKMAN: THEIR RIGHTS AND DUTIES.[2]

THIS pamphlet is one of the twenty-seven unsuccessful essays sent in for competition at the Eisteddfod at Bangor in 1874, and as the adjudicators contented themselves with simply naming the prize winner, making no reference to the merits or demerits of the rejected ones, the author has determined to submit it to the judgment of the public, as several of the other competitors have done. It is a carefully written and well-thought-out summary of the whole duty of master and workman, devoid of anything like violent partizanship, and it will well repay perusal by employer and employed alike.

MATHEMATICAL AND NAUTICAL TABLES.[3]

THE Tables of common Logarithms adopted in this work are taken from the best English authorities, for the simple reasons that in the first place the English have never been surpassed, and in the second place the French and German tables have been copied from English works. It is unnecessary to enumerate the various tables, but there are some small ones entirely new, having been calculated from more accurate formulæ.

It is of octavo size, strongly bound, and bold and clear figures.

PHYSICAL GEOGRAPHY.[4]

THE science of physical geography has attained a position during the last fifteen years that has forced its conclusions and discoveries upon thousands who scarcely knew it as a recognized class of knowledge. It is now seen to affect very many kindred departments of knowledge to such an extent as to make it necessary that every educated person should be familiar with the more difficult and advanced study thereof. But there are few branches of human learning which impart equal delight in the acquisition. The information it attracts is gleaned from almost every field, and yet it belongs exclusively to this particular order. The habits, temperament, customs, sentiments of a race, are to be calculated from its deductions; and the unending branches of natural history, which spring from it as from a tree, or rather flow to it as to a river, give the study thereof a charm few other sciences possess. Dr. Page is not unknown. His book on geology has had a good reception; and this being the eighth edition of his "Physical Geography" is evidence sufficient to prove the general acceptance of his valuable toils.

[1] *First Hints on Rifle-Shooting.* By A. P. Humphrey, Barrister-at-Law. London: William Clowes and Sons. 1876.

[2] *Master and Workman: their Rights and Duties.* An Essay; written for the Bangor Royal Eisteddfod, 1874. By Evan Williams, Bangor.

[3] *Tables, Nautical and Mathematical, for the use of Seamen, Students, Mathematicians, &c.*, arranged, corrected, and some re-calculated, by Henry Evers, LL.D. William Collins, Sons, and Co., London and Glasgow. 1876.

[4] *Introductory Text-Book of Physical Geography.* By David Page, LL.D., F.G.S., &c., &c. Eighth and enlarged Edition. William Blackwood and Sons, Edinburgh and London. 1876.